台灣顯微鏡學會

109年度會議 暨 第40屆學術研討會

主辦單位：台灣顯微鏡學會　協辦單位：國立台灣大學 材料所
工業技術研究院 材料與化工研究所

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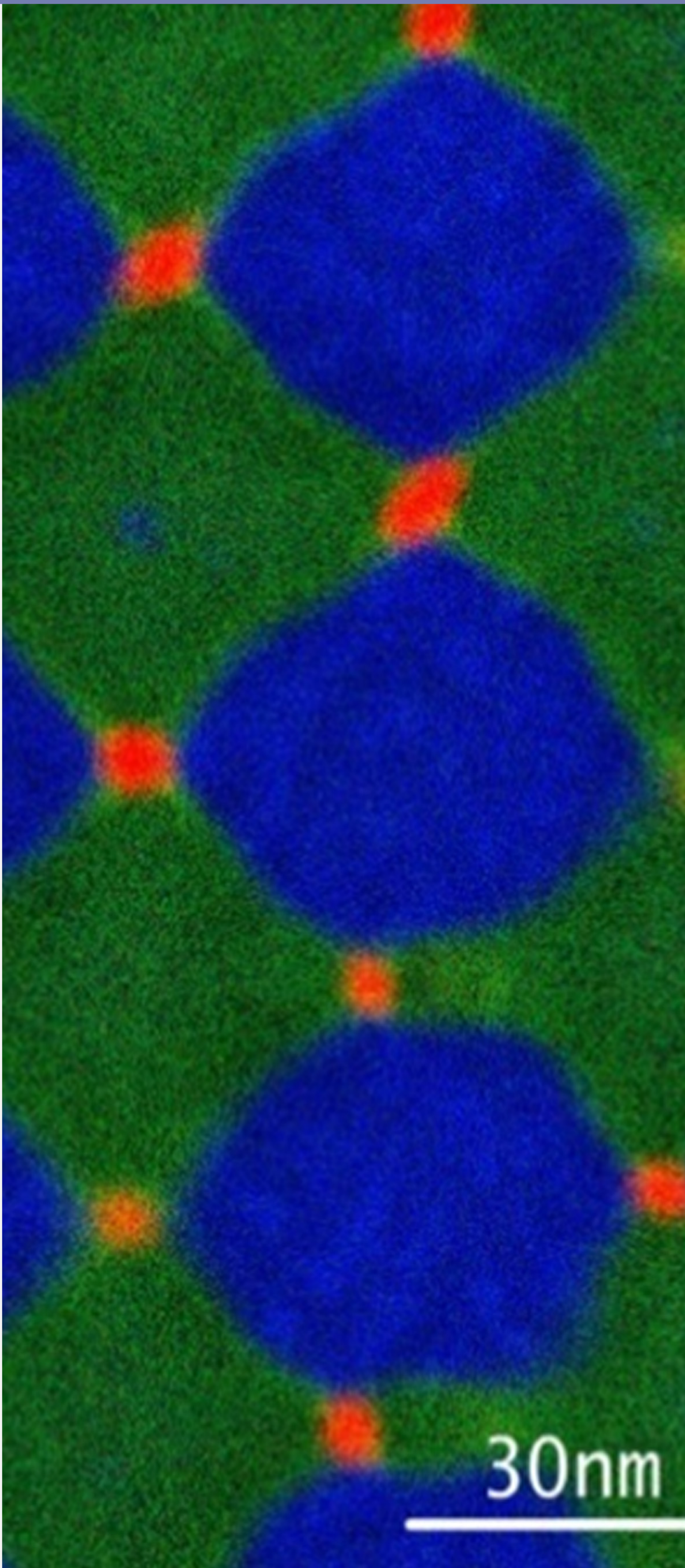

- Application challenges
- Smart STEM / DCFI, AutoSTEM
- DPC, Lorentz, holography
- iDPC Imaging low-Z, beem sensitive or charging materials
- NBED, CBED, CrystalPack
- in situ holders,SW and detectors
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第四十屆臺灣顯微鏡學會年會

109 年 11 月 28 日(星期六) 國立臺灣大學工學院綜合大樓國際演講廳

08:30-09:30	報到
09:30-10:00	開幕
	理事長致詞與會務報告
	會員大會
10:00-11:00	**特邀演講(I)** **眼見為憑方為信-我的生醫顯微探索之路** **To see is to believe (and to convince)- my journey of biological microscopy** **國立交通大學 台灣聯合大學系統 副校長 林奇宏教授**
11:00-11:30	顯微鏡技術推廣(I) GRAND ARM™2 -JEOL New Atomic Resolution Electron Microscope 捷東公司 應用工程部 洪英傑經理
11:30-12:00	台灣顯微鏡學會年會會員大會 Poster Session (地點：一樓大廳)
12:00-14:00	午餐時間 (備有午餐餐盒) Poster Session (地點：205，207，209，228 教室)
14:00-15:00	**特邀演講(II)** **1D- and 2D-Low Dimensional Materials for Innovative Nanoelectronics: How the TEM Help Us to Disclose Microstructures towards Composition/Phase Engineering** **國立清華大學 材料科學工程學系 闕郁倫教授**
15:00-15:30	顯微鏡技術推廣(II) Spectra 300: High Resolution TEM and STEM microscope for all materials science applications Jason Chen, Field Application Supervisor, Thermo Fisher Scientific
15:30-16:00	討論交流時間（一樓大廳備有點心茶點 ）
16:00-16:30	顯微鏡技術推廣(III) In-situ Microstructure analysis and Mechanical Property Measurements in Electronic Microscopes 台灣布魯克 Po-Jen Wei 魏伯任
16:30-17:00	頒獎、閉幕

台灣顯微鏡學會

第十九屆理、監事當選名單

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	呂明諺	國立清華大學材料與工程學系	教授

第四十屆台灣顯微鏡學會學術研討會
邀請演講

林奇宏教授 Prof. Chi-Hung Lin

現　　職：
國立交通大學 台灣聯合大學系統 副校長
國立交通大學 生物科技學系 教授
國立交通大學 生物科技學系 講座教授
國立陽明大學 微生物及免疫學研究所/微生物科 教授
國立陽明大學 生醫光電所 教授
國立陽明大學 臨床醫學研究所 教授
國立陽明大學 傳統醫學研究所 教授
國立陽明大學 食品安全及健康風險評估研究所 教授

學　　歷：
美國耶魯大學 生物系 博士
中華民國台灣國立陽明大學醫學院 醫學系 & 醫學士

專　　長：
細胞生物學、癌症生物學、生醫光電、基因體學

演講題目：眼見為憑方為信- 我的生醫顯微探索之路
To see is to believe (and to convince)- my journey of biological microscopy

I will spend the hour recollecting how I, trained as a medical doctor, happened to diverge into this fascinating world of biological microscopy.

"I took the path less travelled by, and that has made all the difference. " ~ Robert Frost"
It surely made a difference on me. Several microscopic techniques and bio-photonic tools that enabled my research careers will be reviewed to exemplify what challenges a biologist would encounter to comfortably apply these methodologies to address the biological questions in which he or she is interested. I will also depict a blueprint regarding if and how "contract microscopy services" can be developed into a business model (or NPO) to serve the biomedical society.

第四十屆台灣顯微鏡學會學術研討會
邀請演講

闕郁倫教授 Prof. Chi-Hung Lin

現　　職：
國立清華大學 材料科學工程學系 教授
國立中山大學 物理學系 合聘教授

學　　歷：
國立清華大學 材料科學工程系 博士
國立清華大學 材料科學工程系 碩士
國立中山大學 物理學系 學士

演講題目：1D- and 2D-Low Dimensional Materials for Innovative Nanoelectronics: How the TEM Help Us to Disclose Microstructures towards Composition/Phase Engineering

ow dimensional nanomaterials have attracted much attention due to their unique fundamental properties and their potential applications in nanodevices. Nanoscale materials, compared to their bulk dimensions, can possess superior electrical, optical, and mechanical properties, resulting in excellent mechanical toughness, high luminescence efficiency, enhancement of thermoelectric property and low lasing threshold voltage. Most importantly, the synthesis of nanomaterials is a critical step for the application of innovative nanodevices. In this talk, I will focus on the finely controllable synthesis of various novel low dimensional materials, including 1D nanowire and 2D layered materials such as TMDs and graphene toward the exploration of unique physical properties. The studies of microstructures to towards different controllability such as compositions and phases on these 1D- and 2D-low dimensional structures will be introduced. In addition, the how the applications based on these novel 1D- and 2D- low dimensional materials into innovative nanoelectronics such as transistor, memory, photo-sensors and gas sensors will be introduced.

GRAND ARM™2 -JEOL New Atomic Resolution Electron Microscope

Yieng-Chieh Hung（洪英傑）

Department of Application, Jiedong Co.,Ltd, Hsin-Chu, Taiwan

In the beginning of 2020, JEOL introduce brand new Ultrahigh Atomic Resolution Analytical Electron Microscope JEM-ARM300F2-GRAND ARM™2. As the flagship TEM of JEOL, it set a new milestone for top level TEM by following features

- FHP2 new objective lens pole-piece — Optimize X-ray solid angle and take-off angle, which improve the detection efficiency of EDS.
- New enclosure — Provide more capability to reduce environmental interference, such as temperature, air flow, acoustic noise and so on.
- ETA corrector & JEOL COSMO™ — provide Quick and Accurate aberration correction
- CFEG Stability improvement — New SIP , smaller but with more pumping capability, which improve CFEG vacuum and stability.

Spectra 300 S/TEM for Materials Science: The ultra-high resolution, "all-in-one" solution for atomic scale materials characterization

Jason Chen (陳弘昇)*, and Edward Tang (唐健峰)

Materials & Structural Analysis Division (MSD), Thermo Fisher Scientific, Taiwan
*Jason.Chen1@thermofisher.com

The Spectra 300 S/TEM is the highest resolution imaging and spectroscopic platform from Thermo Fisher Scientific. With its wide-gap pole piece and an accelerating voltage range of 30–300 kV, it also serves the widest range of materials investigations.

The highest-resolution structural and chemical information at the atomic level. The Thermo Scientific™ Spectra 300 S/TEM combines:

- Redesigned, high-stability base
- New ultra-high resolution (X-FEG UltiMono) source or a ultrahigh brightness (X-CFEG) source
- Image and 5th order probe aberration correction (S-CORR)
- Single electron sensitive STEM detection
- Sensitive energy dispersive X-ray (EDX) detectors

By synchronizing these technologies through our advanced software and automation modules, the Spectra 300 S/TEM makes accessing the highest-resolution atomic-scale information more efficient, easy and repeatable than ever.

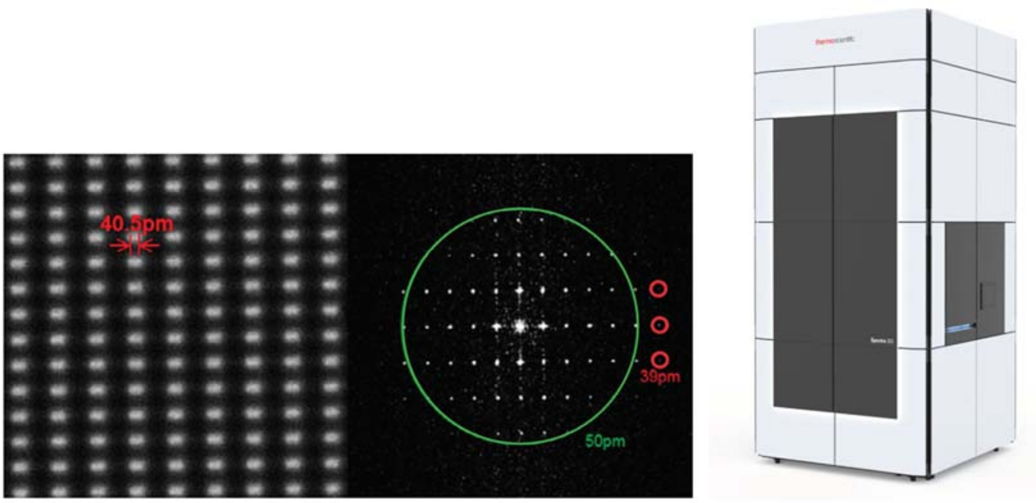

Figure 1. HAADF (DCFI) STEM image of GaN [212] at 300 kV showing 40.5 pm Ga-Ga dumbbell splitting and 39 pm resolution in the FFT on a wide gap (S-TWIN) pole piece.

In-situ Microstructure analysis and Mechanical Property Measurements in Electronic Microscopes

Po-Jen Wei 魏伯任
Applications Scientist, Nano Surface Division, Bruker Corporation
Pal-Jen.Wei@bruker.com

Bruker's Hysitron PicoIndenters are comprehensive in-situ nanomechanical testing instruments for TEM, SEM, and FIB/SEM. Based on Bruker's leading capacitive sensor technology, the PicoIndenters provide researchers with a powerful advanced instrument with excellent versatility. In addition to directly using the indentation function to compress the micro-pillars, particles and other small-sized structures can measure the stress-strain behavior and yield characteristics and observe the deformation mechanism in real time. The push-to-pull (PTP) device can be used to measure the tensile stress-strain behavior of samples such as nanometers and thin films. With the use of the ECM function with electrical signal acquisition and the electrical push-to-pull (E-PTP) device, the resistivity of the sample can be measured by the standard four-point measurement method while the tensile test is performed.

In addition, after deformed the sample we could analyze with detectors such as EBSD, EDS, or WDS to obtain a deeper understanding of the material’s mechanical response. Microstructure and texture evolution can be quantified when combining this technique with EBSD. This combination could also be used to extend the scope of research related to other advanced textured, anisotropic, or multi-phase materials.
The quantitative results can then be used for refining the plastic deformation theory as well as for confirming the existing simulation model

第四十屆臺灣顯微鏡學會年會研討會

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Investigation of Charging/Discharging Behaviors of Spinel High Entropy Oxides for Lithium Energy Storage System at Atomic Scale

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Lithium ion batteries (LIBs) are the most popular energy storage system owing to their excellent properties [1]. Research on new electrode material becomes more and more crucial. Transition metal oxides (TMOs) are great of interest in electrode material for next generation due to their multi-electron redox process, resulting in excellent capacity. However, large volume change during charging/discharging cycle still needed to be improved. Nowadays, high entropy materials (HEMs) have been applied for stabilizing the structure by high configurational entropy [2]. Based on the mentioned above, transition-metal high entropy oxides (TM-HEOs) would be suitable for anode materials of LIBs. However, research on spinel HEOs applied in LIBs is lacking. In this work, spinel HEOs (Fig. 1) are successfully applied as anode material in LIBs, and the mechanism and behaviors are firstly reported. The detailed information of structure and electrochemistry provided in this study would be helpful for the development of lithium energy storage system in the future.

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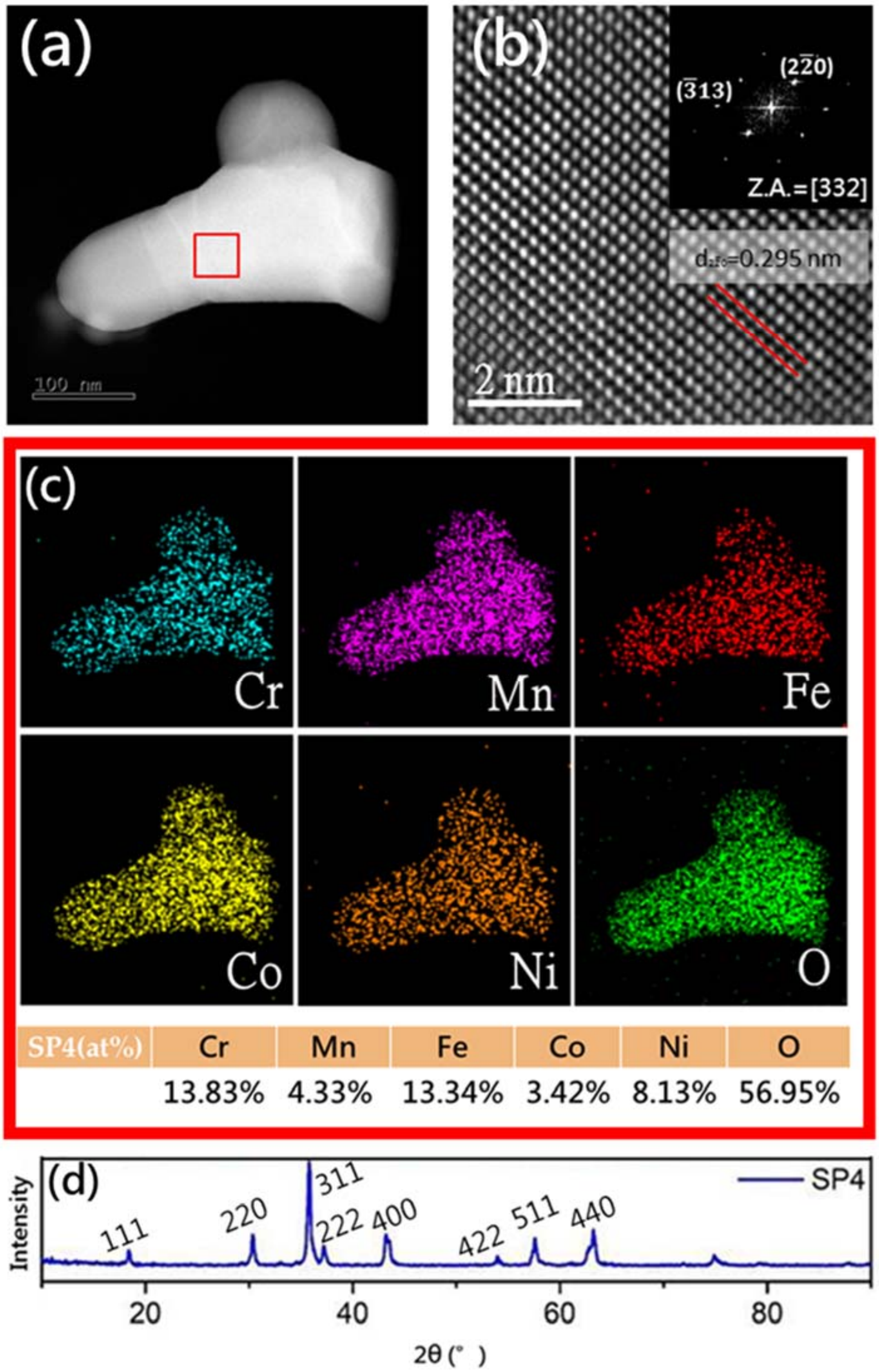

Figure 1. The identification of original HEO particles.

Applications of Functional Dielectric Materials Structure in Energy-Efficient RRAM with Self-compliance

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Resistive Random Access Memory (RRAM), which has high switching speed and cost effective priority, is potential to applicate in large-scale computing system. The transition metal oxides have been utilized as the switching layer in RRAM device for decades owing to the stable structure and variable oxidation state of transition metal.[1] In this work, a functional RRAM device (Pt/AlO_x/ZnO/Ti) has been constructed, and the resistive switching process could be controlled by voltage supply. The power consumption of set and reset process are 0.586 nW and 0.596 nW, respectively, and the forming process is not required for this device. Additionally, the resistance decreases to 10^6 Ω while switching to low resistance state, and the current level could maintain in about 10^{-5} A without setting compliance current. Also, the device could operate exceed for $3x10^3$ times. The distribution of oxygen vacancies in low resistance state (LRS) has been analyzed by Scanning transmission electron microscope (STEM) image, Electrons energy loss spectrum (EELS), which provided evidence of the continuous oxygen vacancies filaments in ZnO and discontinuous oxygen vacancy in AlO_x layer. The Pt/AlO_x/ZnO/Ti RRAM device has excellent electrical properties, and its switching mechanism has been demonstrated by advanced TEM techniques.

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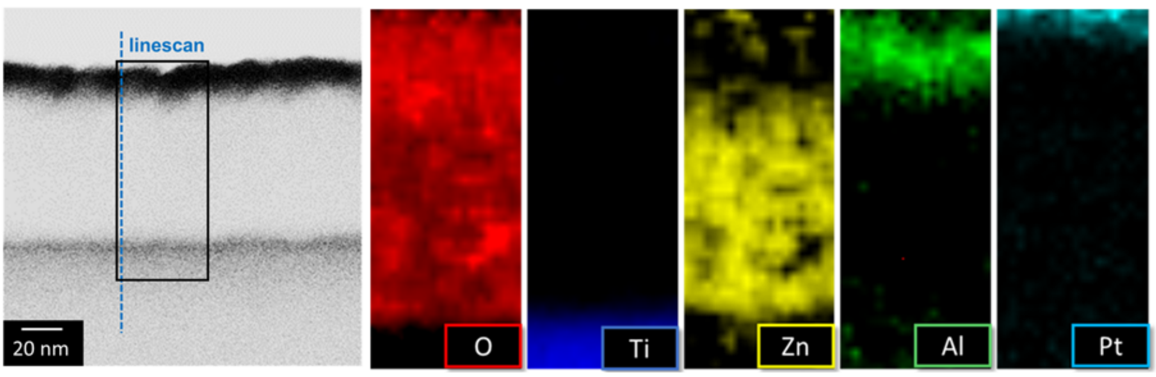

Figure 1. STEM image and EELS mapping of Pt/AlO_x/ZnO/Ti RRAM structure.

Dynamic Observation of Electromigration in High Density Electroplated Nanotwinned Copper through In-situ TEM

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In this study, we introduce high-density electroplated nanotwins into copper, and the EM rate on surface can be measured through *in-situ* transmission electron microscope(TEM). The EM rate has found to be retarded at the triple points, which is significantly slower than previous researches, and improve the durability of the device[1]. Furthermore, the free surface where a twin intersects is transform to a zigzag surface, consisting of alternating (200)/(111) planes. And Cu atoms were gradually removed along (111) when applying a current with a density of 10^4 A/cm^2.

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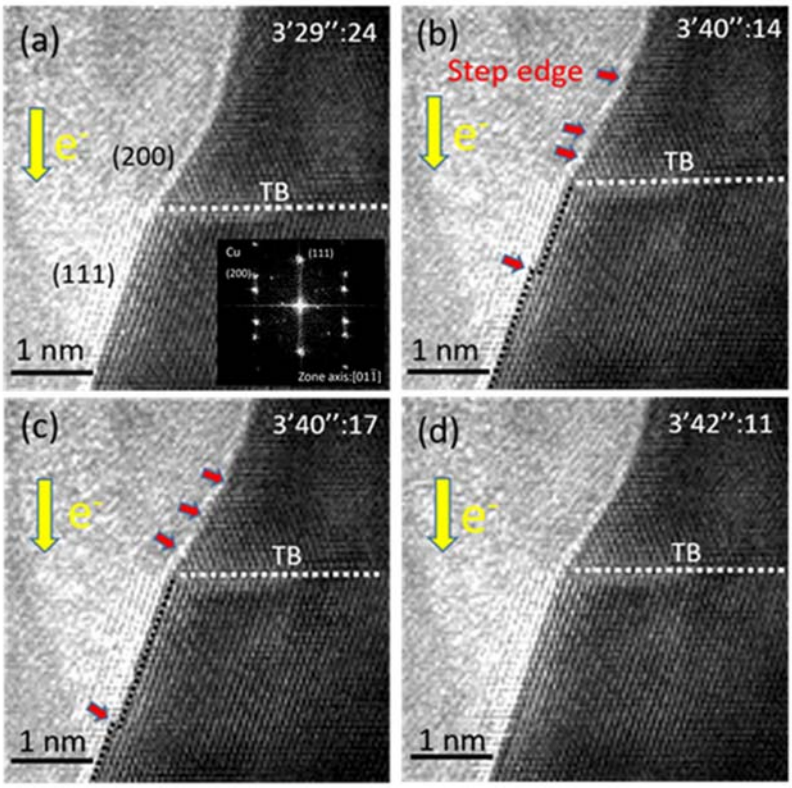

Figure 1. (a)-(d) HRTEM images showing the process of high density nanotwinned Cu with current density of 3.5×10^4 A/cm^2.

In Situ TEM/STEM Observation of Atomic-Scale Tungsten Disulfide Localized Thinning and Reconstruction

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In situ observations *via* transmission electron microscopy (TEM) and STEM are powerful methods to examine the authentic behavior of atoms under electron beam irradiation [1, 2]. In this study, the dynamic behavior of tungsten disulfide (WS_2) has been explored. Notably, we focused on the connection of the layer number and electron beam irradiation. Samples with different layer numbers were compared, and the variations were analyzed. Last, detailed atomic structure and element analyses were performed to generate direct evidence of the mechanism of the behaviors. This investigation demonstrates the structural evolution of WS_2 and elucidates the effects of electron beam processing on WS_2.

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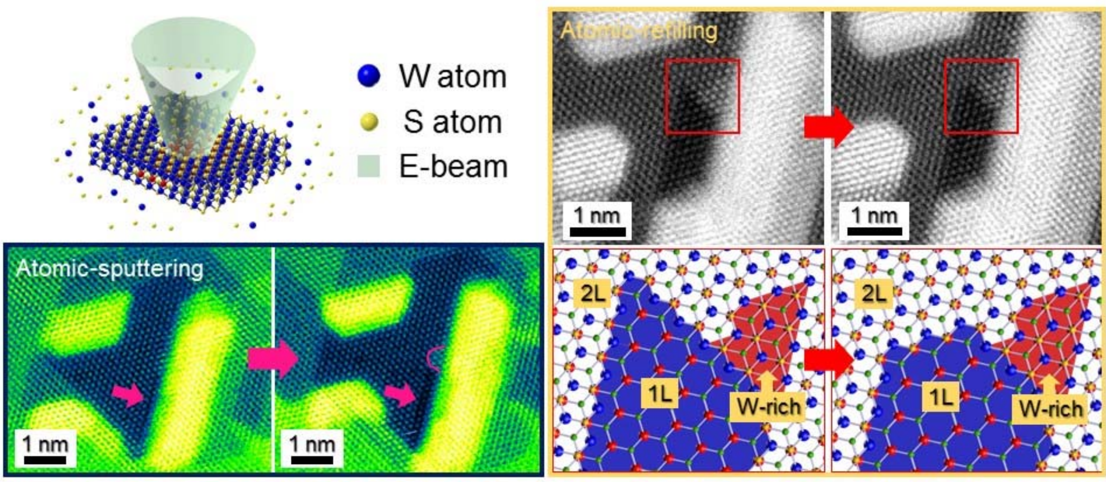

Figure 1. The sub-nm electron beam processing of atomic layered WS_2 has been demonstrated through *in situ* TEM/STEM to explore nanofabrication techniques toward two dimensional materials.

Atomic-scale Silicidation of Low Resistivity Ni-Si System through *In-situ* TEM Investigation

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In order to realize the dynamic formation mechanism of Ni-Si system, we used *in-situ* transmission electron microscopy (TEM) to record the diffusion behavior during the heating process [1] [2]. In this study, three-steps annealing process to synthesize different nickel silicides corresponding to the various formation temperatures were investigated systematically. At 250 °C, the product of the first-step annealing was inverted-triangle Ni_2Si, embedded in the Si substrate. Then, well-distributed NiSi thin film was synthesized, having the lowest resistivity among Ni-Si system at 400 °C. Finally, $NiSi_2$, a Si-rich product, would form during the third-step annealing at 600 °C. We provide the evidence of diffusion behaviors and structural identification of Ni-Si system.

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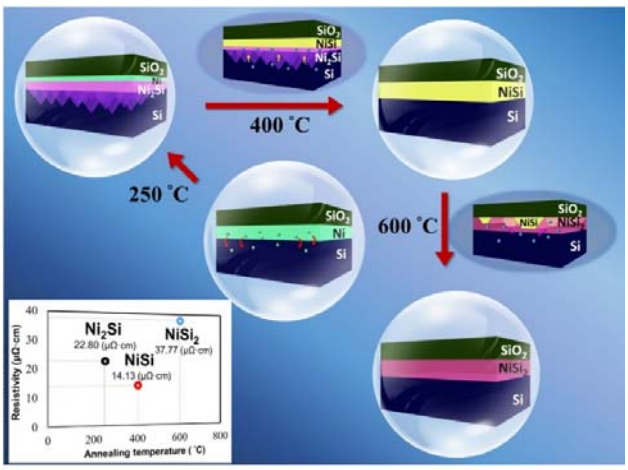

Figure 1. Schematic illustration of phase transformation of Ni-Si system.

Topotactic Phase Transformation and Resistive Switching Behaviors of $SrCoO_x$ RRAM Device Investigated by In-situ TEM

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Resistive random access memory (RRAM) has been regarded as a candidate for next generation nonvol- atile memory [1,2] (NVM) due to its low cost, low power consumption, high stability and high switching speed. In this study, we deposited $SrCoO_x$ (SCO) on a niobium-doped $SrTiO_3$ substrate as the dielectric layer via pulsed laser deposition (PLD). The novel SCO device possesses excellent RRAM properties. Furthermore, the switching mechanism was investigated by using ex-situ and in-situ transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM), which showed that the switching behavior resulted from the topotactic phase transformation. The discussion of this switching behavior provides support for a novel aspect of the RRAM switching mechanism.

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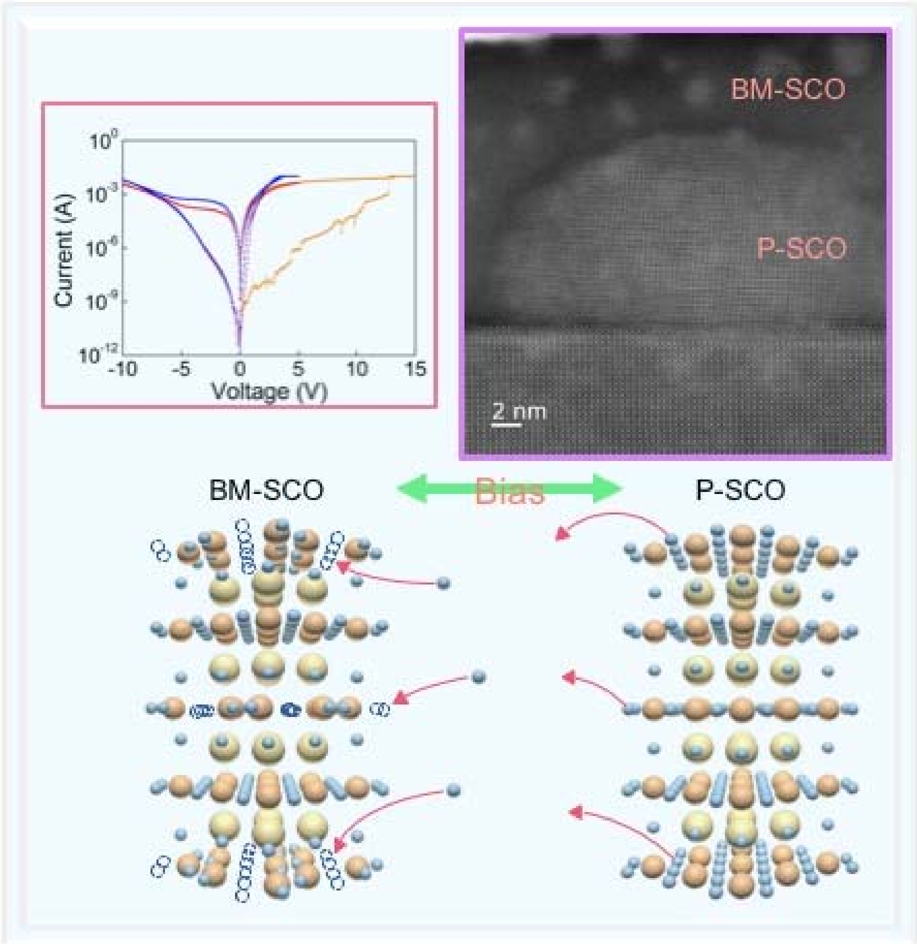

Figure 1. This study provides not only the switching mechanism of the SCO RRAM devices, which resulted from the topotatic phase transformation between BM-SCO and P-SCO, but also the novel aspect for the RRAM dielectric materials.

The nucleation mechanisms of precipitates in the AA2050 aluminium alloy

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In this study, Cs-corrected high-angle-annular-dark-field scanning-transmission-electron microscopy (Cs-corrected HAADF-STEM) and small angle X-ray scattering (SAXS) were employed to investigate the microstructure evolutions of nanometer-sized precipitates in the Al-Cu-Li (AA2050) aluminium alloy. GP zones such as GP(T_1), GP(θ''), and GPB zones were found to be the precursors of T_1(Al_2CuLi), θ' (Al_2Cu), and S (Al_2CuMg) precipitates, respectively. The transformation mechanisms of GP(θ'') → θ', have not been elucidated. In steels, the transition of carbides such as the separated nucleation, sympathetic, and in-situ nucleation has been explored in previous work [1, 2]. In aluminium alloy, the nucleation mechanisms of precipitates occur in the AA7050 aluminium alloy [3]; however, the detailed atomic structure has not been elucidated. The present study aimed to confirm these nucleation mechanisms of θ' in the creep age forming (CAF) treatment by Cs-corrected HAADF-STEM. Moreover, it is hoped that the in-situ heating SAXS and anomalous SAXS to identify these nucleation mechanisms.

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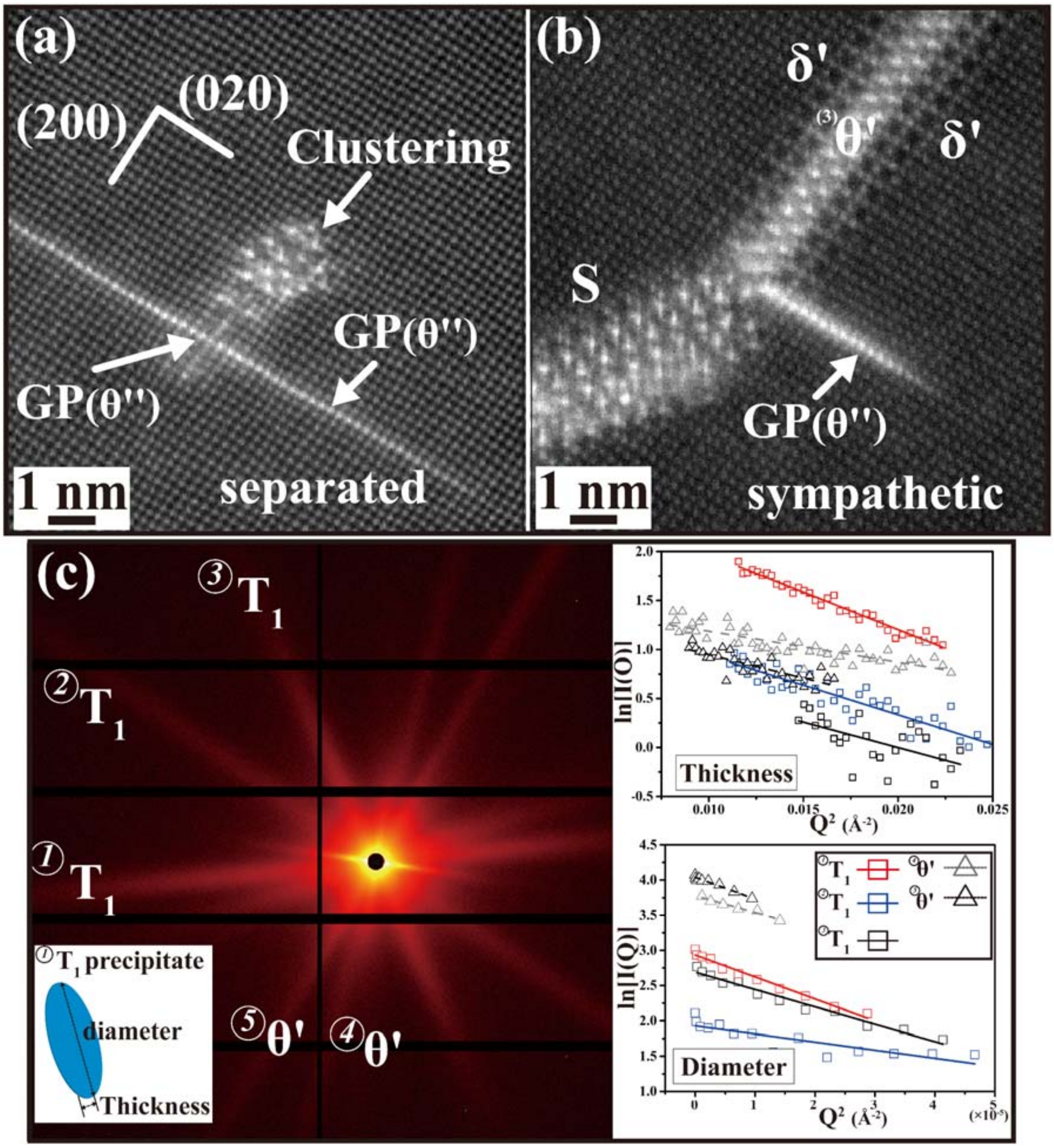

Figure 1. (a, b) HAADF-STEM images, along the zone $[100]_{Al}$ axis showing the formation mechanisms of precipitates in AA2050 alloys. (c) The streak-like 2D SAXS pattern and ln[I(Q)]-Q^2 curves revealing the disc-like precipitates and their corresponding sizes. (Q: scattering vector and I(Q): intensity)

Atomic lattice defects in η_{12} precipitate of the Al-Zn-Mg-Cu aluminium alloy

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For Al-Zn-Mg-Cu aluminium alloys, 13 types of η precipitates would possess the symmetrically variants distributed on the closed plane of the Al matrix parallel to the $\{0001\}_\eta$, $\{2\bar{1}\bar{1}0\}_\eta$, or $\{10\bar{1}0\}_\eta$ interfaces of precipitates [1, 2]. It was reported that the η_{12} precipitates, growing on the$(0001)_{\eta12}$ // $(1\bar{1}3)_{Al}$ habit plane where the growth direction follows with $[2\bar{1}\bar{1}0]_{\eta12}$ // $[110]_{Al}$, are characterized with the atomic zig-zag configuration [1]. However, whether during the dynamic precipitation of creep age forming, the growth of η_{12}, subjected to the dislocation movement, would be induced the atomic lattice defects has yet to be elucidated. In the present work, along the $[2\bar{1}\bar{1}0]_{\eta12}$ // $[110]_{Al}$ zone axis, compared to the uniform zig-zag stackings of η_{12}, the higher aspect ratio elongated hexagonal defects incorporated with Penrose tiling features are characterized as the atomic lattice defects as the dynamic precipitation of creep age forming.

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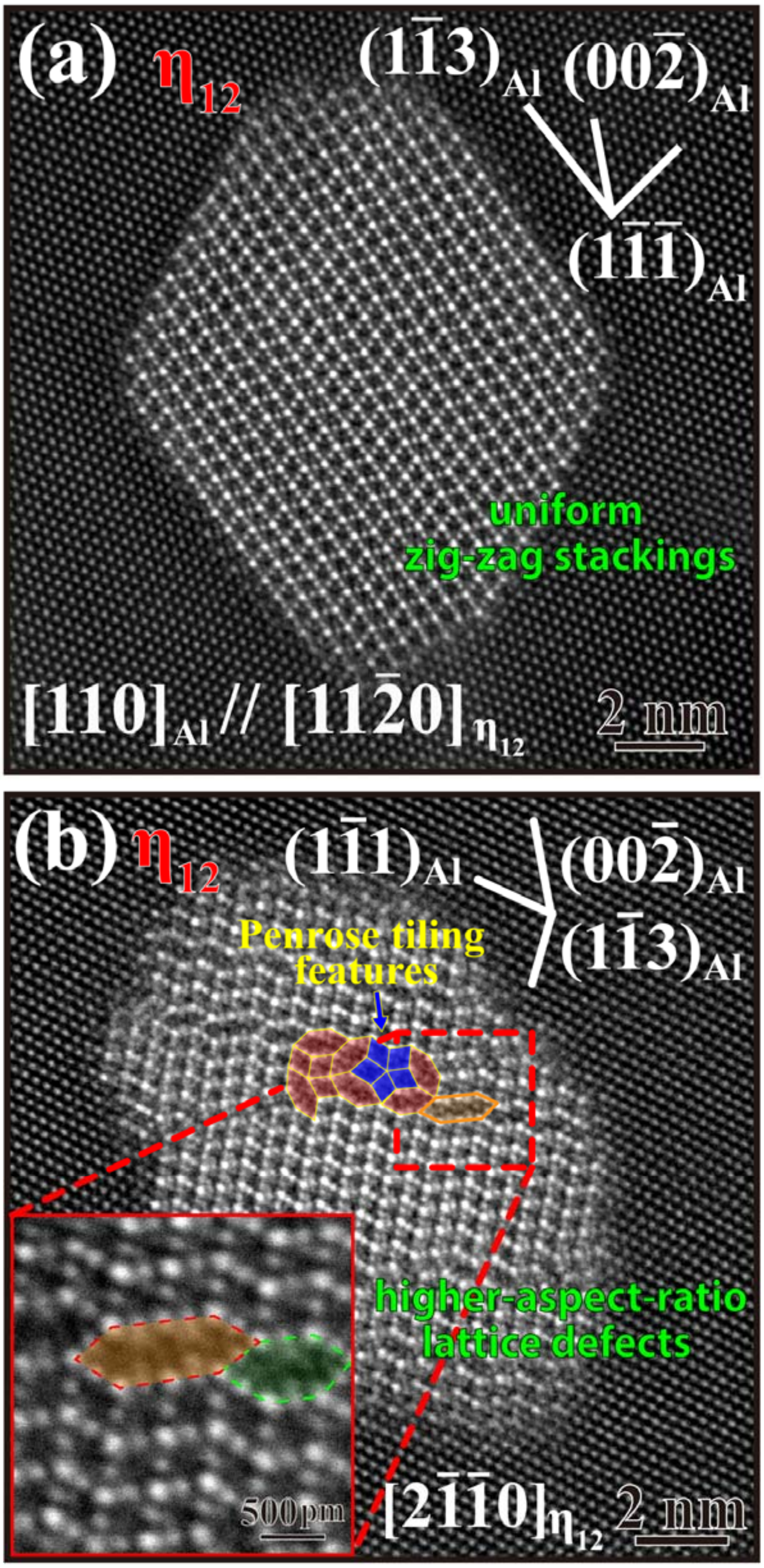

Figure 1. HAADF-STEM images, along the zone axis of $[2\bar{1}\bar{1}0]_{\eta12}$ // $[110]_{Al}$, showing (a) the uniform zig-zag stackings of η_{12} and (b) the higher aspect ratio elongated hexagonal defects with Penrose tiling features in another η_{12}.

A solution offering a large-scale, damage-free, polished surface for failure analysis of advanced heterogeneous packaging

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Three-dimensional architecture comprising individual dies and wafers connected by through silicon via (TSV) structures in silicon interposers is a way to improve the performance of a chip. The technology is under development and defects, such as the filling materials in TSVs in interposer and heterogeneous conjunction, are the cause of most failure problems in a device. It is desired to investigate a flat and damage-free cross-section surface of a device for imaging and analysis. Fischione Instruments' newly launched ion milling system, the Model 1062 TrionMill, is an ideal tool to provide large-scale milling of planar samples up to 50 mm and cross-section samples up to 5 mm in width.

Figure 1 illustrates the effects of ion milling to remove artificial defects introduced by mechanical treatment. A semiconductor device containing solder bumps was embedded in resin and mechanically prepared with #1200 sandpaper. Figure 1 shows results of mechanical preparation; the scratches and contamination can be easily observed. Not only is the surface of the solder affected by mechanical preparation, but also the entire volume, including solder bumps and copper pads. Mechanical preparation can introduce artifact defects, such as delamination or cracks. Figure 2 shows that all surface damage (scratches and residual particles) introduced by mechanical preparation were removed by ion milling at 6 keV beam energy and 3° beam angle in only 30 minutes. The fine microstructure at the interface of the solder junction is resolved. However, if previous mechanical preparation introduced defects into the solder connection, the defects will still be present. The solution is to prepare a target row of solder bumps by a single ion milling process as shown in Figure 3. The device was carefully cut close to the target solder bump row. The bumps were not affected by mechanical action. Then, the sample was affixed to a protective mask, which was aligned at the center of the bumps. After a single ion milling process using the Model 1062 TrionMill, a row of 12 solder bumps was exposed (Figure 3a) and shows a completely artifact-free microstructure (Figure 3b-c).

Fig. 1. SEM backscatter contrast images of solder bumps ***after mechanical polishing***.

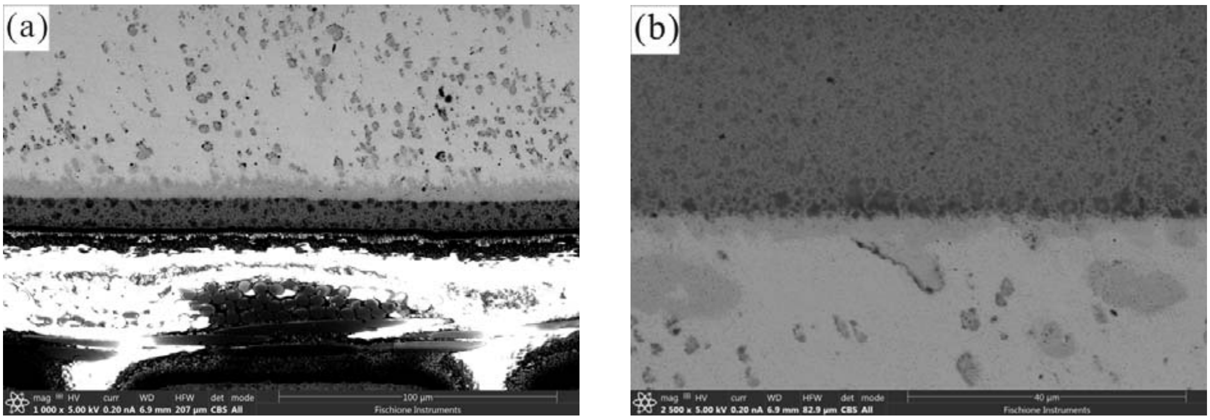


Fig. 2. The same areas shown in Figure 1 ***after broad ion beam milling***.

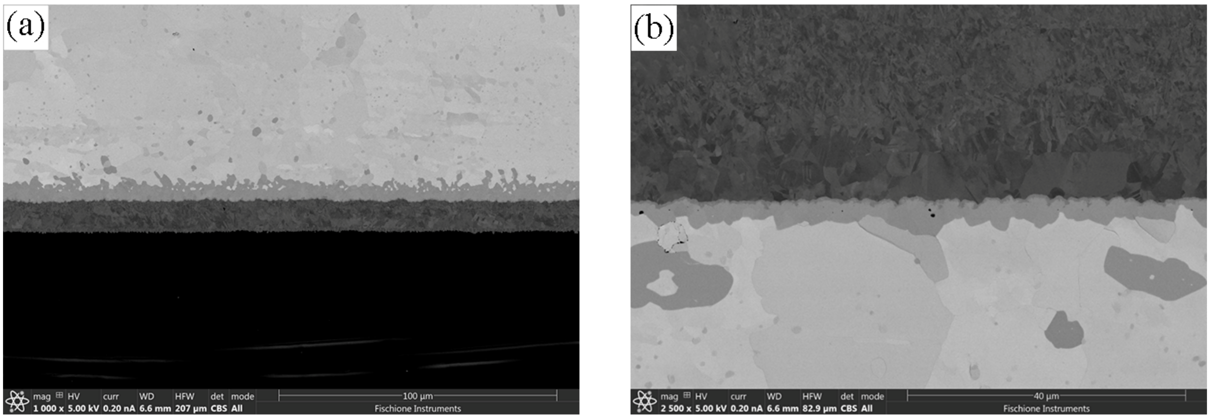
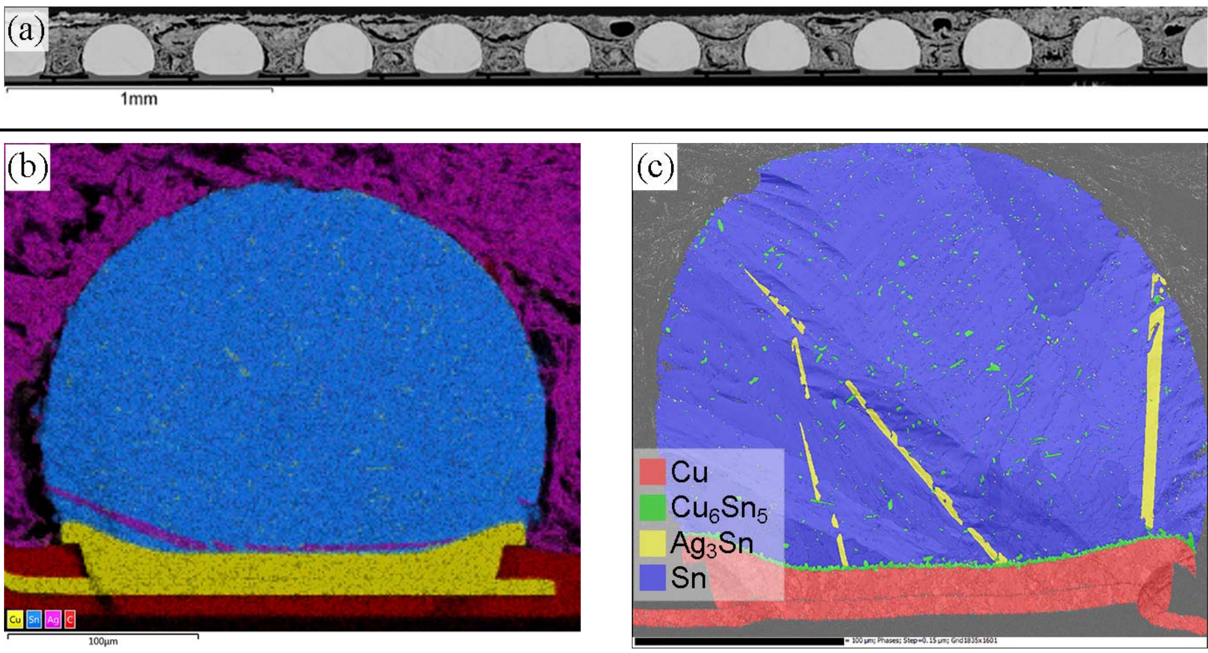


Fig. 3. (a) SEM backscatter contrast image of a cross-section sample showing 12 solder bumps, (b) EDS map of bump 10, and (c) EBSD phase distribution map of bump 3.



Hierarchical twinning structures of the bulletproof FeCoNiCrMn high entropy alloys under the cryogenic environment

Tsai-Fu Chung[1], Cheng-Ling Tai[1], Yo-Shiuan Lin[1], Chien-Nan Hsiao[2], Wei-Chih Li[3], Jien-Wei Yeh[4], Woei-Shyan Lee[5], Jer-Ren Yang[1,*]

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Under the cryogenic environment, 70% Cold-rolling FeCoNiCrMn high entropy alloys, subjected to high-speed deformation (~9×10^3 s^{-1}), achieve an excellent mechanical strength of ~3.3 GPa with a good ductility of ~31.9%. The bimodal grain sizes significantly are divided by the characteristic structures of annealing twinning, promoting an efficient refinement strengthening. Notably, under high-speed deformation at the cryogenic temperature, the narrow strips of the matrix, which are related to the formation of profuse lamellar annealing nanotwins, effectively are refined by deformation nanotwins, leading to the dynamic grain refinement and the work hardening.

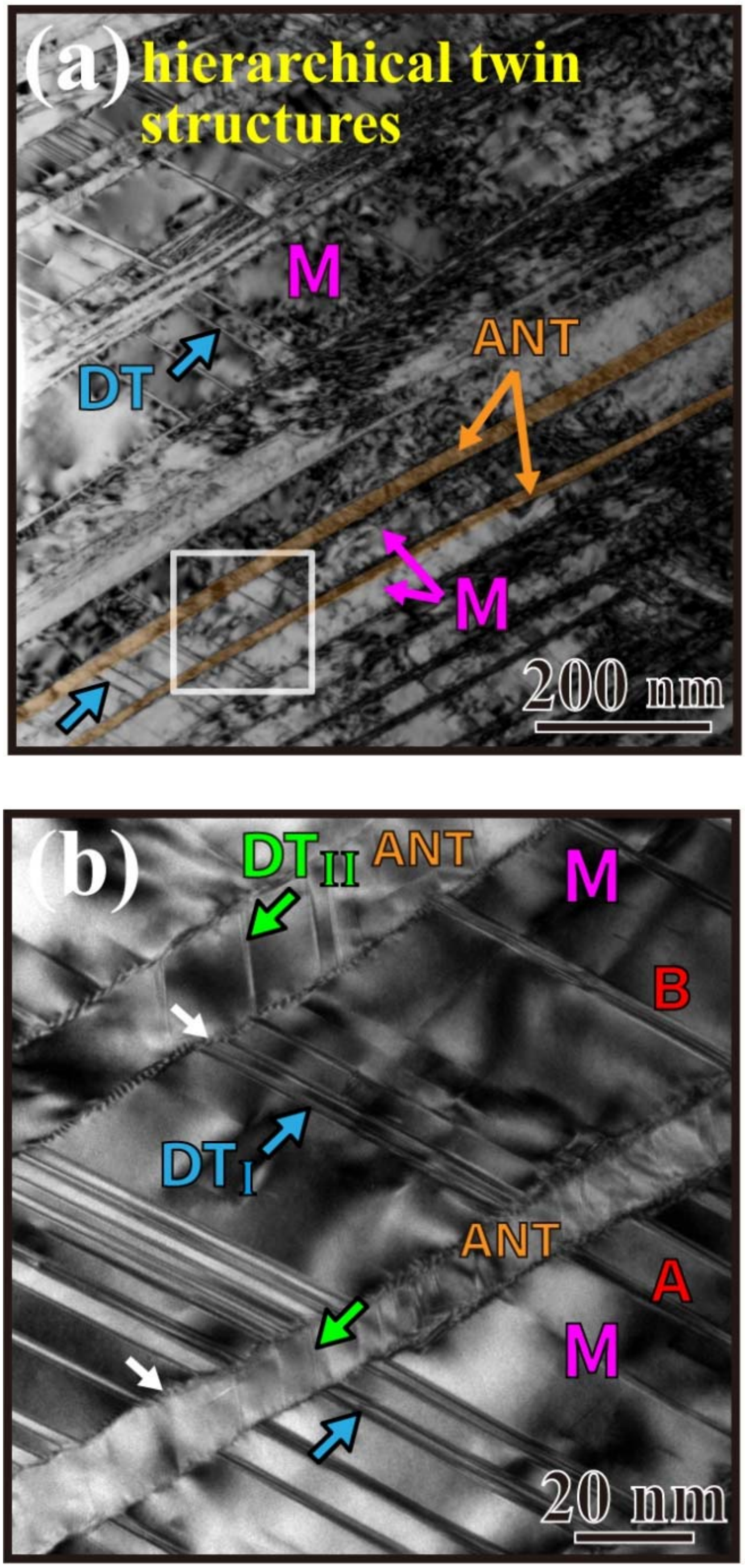

Figure. Hierarchical twinning structures of the bulletproof FeCoNiCrMn high entropy alloys.

多層次 FeCoNiCr 高熵合金結構之退火奈米雙晶中的變形奈米雙晶演化

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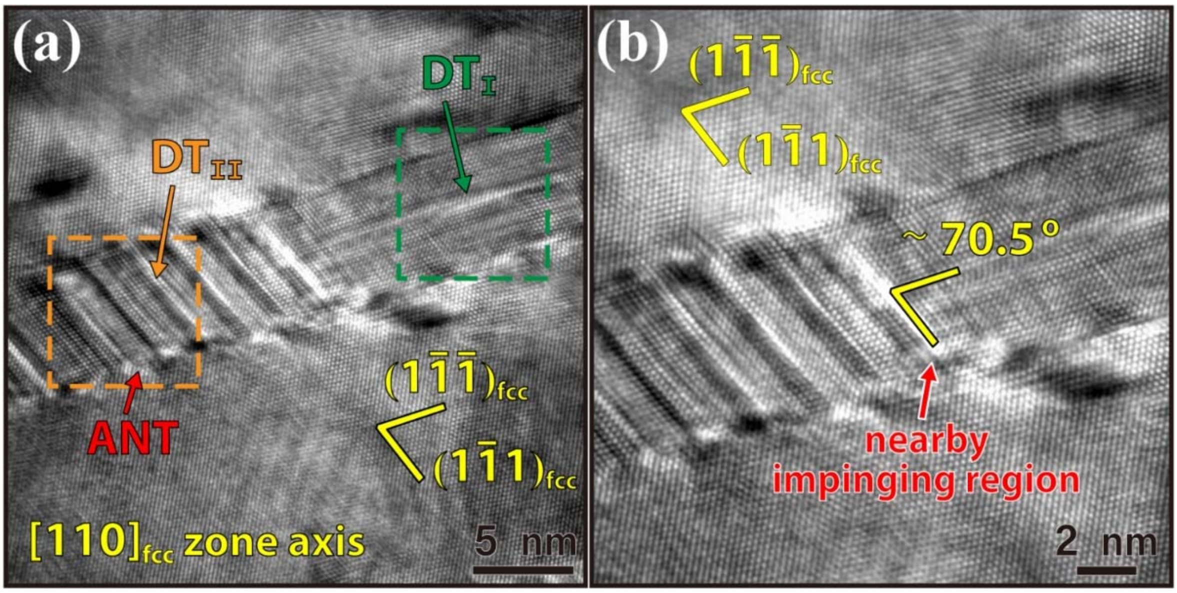
擁有低疊差能之 FeCoNiCr 高熵合金，於一般時效退火溫度下，孕育出大量微米等級與奈米等級退火雙晶結構，促使 FeCoNiCr 高熵合金呈現多層次顯微結構組織。特別地，奈米等級退火雙晶成長於 FCC 金屬之最密平面上，即，空間上$(1\bar{1}1)_{fcc}$與$(1\bar{1}\bar{1})_{fcc}$平面。於高速撞擊下，奈米等級退火雙晶之晶界承受大量應力變形與差排缺陷的累積，逐漸成疊差的成核點。隨著高速撞擊過程中，大量的疊差亦轉變為奈米變形雙晶。而分布於奈米等級退火雙晶結構中的奈米變形雙晶，亦於空間上$(1\bar{1}1)_{fcc}$與$(1\bar{1}\bar{1})_{fcc}$平面發展。最終，更進一步地細化奈米等級退火雙晶結構。進而達到動態細晶強化效果。



圖：高速撞擊過程中，奈米等級退火雙晶(annealing nanotwin，ANT)結構中，誘發兩個$(1\bar{1}1)_{fcc}$與$(1\bar{1}\bar{1})_{fcc}$平面上的奈米變形雙晶(deformation nanotwin，DT_I與DT_{II})。

Reveal the 3D topology of the interface between crystalline and amorphous structures by atomic electron tomography

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2D projection is typically insufficient to understand 3D density distribution within nano-materials. Atomic electron tomography is capable of retrieving the 3D structure from a tilted series of projections. However, it is challenging to characterize the interface between crystalline and amorphous structures due to two major difficulties: the missing wedge problem and the radiation damage. By combining a rod-shaped specimen and a low-dose tomography algorithm, generalized Fourier iterative reconstruction (GENFIRE), we determine the 3D profile of the interface between Platinum and oxide deposited on the FinFET.

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Algorithm for characterizing the subcellular structures of nanometer-sized biological specimens in a solution using x-ray free-electron lasers

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Coherent diffraction imaging using third generation synchrotron sources and x-ray free-electron lasers has been demonstrated to be an excellent tool for revealing the inner structures of a single particle. The primary challenge in imaging pure, tiny, and isolated biological specimens is obtaining a reliable reconstruction from diffraction data that have a poor signal-to-noise ratio. Thus, we developed a robust method that yields the internal density distribution of liposome vesicles immersed in a solution. By combining the guided hybrid input-output method and a new order parameter defined by the consistency of the reconstruction, we, without prior knowledge, retrieved both pure and drug-containing liposome vesicles from individual diffraction patterns. This result is currently the smallest noncrystalline biological specimen resolved by single-shot coherent diffraction microscopy.

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Position correction and mixed-states decomposition in ptychographic reconstruction

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Ptychography is a scanning imaging method based on the technique of coherent diffraction imaging (CDI). Diffraction patterns are collected at several scanning points with overlapping illumination areas. Many factors in experiments might deteriorate the quality of reconstruction, such as inaccurate position information, instability of the sample and detector, and the incoherence of the light source. Here we implement the multi-mode extended ptychographic iterative engine (Mm-ePIE) with position correction to address the aforementioned issues. The feasibility of the algorithm is verified by simulation and UV experiment.

Specimen Preparation for TEM Tomography

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Most recently, it has been demonstrated that one can obtain 3D atomic structures within nanomaterials by high-resolution scanning-transmission-electron-microscope (STEM) Tomography. However, the distorted 3D reconstruction due to the missing images at high angles (i.e., missing wedge problem) is the most common challenge in this field. We generate rod-shaped TEM specimens using the milling and the lift-out technique of Focused Ion Beam (FIB) to solve the above issue. In this study, the preparation procedures and TEM images of the specimen will be presented.

Structural Investigation of Conducting Filaments in Ta_2O_{5-x}-based Resistive Random Access Memory

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Abstract

Over the past decades, resistive random access memory (RRAM) has attracted much attention as the potential candidate among next-generation non-volatile memories [1]. Among the various transition metal oxide, Ta_2O_5 (with wide bandgap of 4.4 eV), is the most commonly used switching layer in RRAM due to its excellent performance [2]. However, the direct evidence for understanding of structure transformation during resistive switching was insufficient, and the influence of electric field on active electrode should also be considered. In this work, a well-performance Pt/Cu/Ta_2O_{5-x}/Pt/Ti/Si device with stable resistance states and large ON/OFF ratio (>10^6) was fabricated to investigate the resistive switching behaviors. Moreover, from the high-resolution transmission electron microscope (HRTEM) images and corresponding Fast-Fourier-Transform Diffraction pattern (FFT-DP), a conducting filament composed of Cu atoms can be observed near the bottom electrode. It is convinced that the electric field would induce the migration of active atoms and lead to the resistive switching. The atomic scale observation of conducting filaments through advanced TEM investigation provides a novel and direct method to realize the switching mechanism for RRAM devices.

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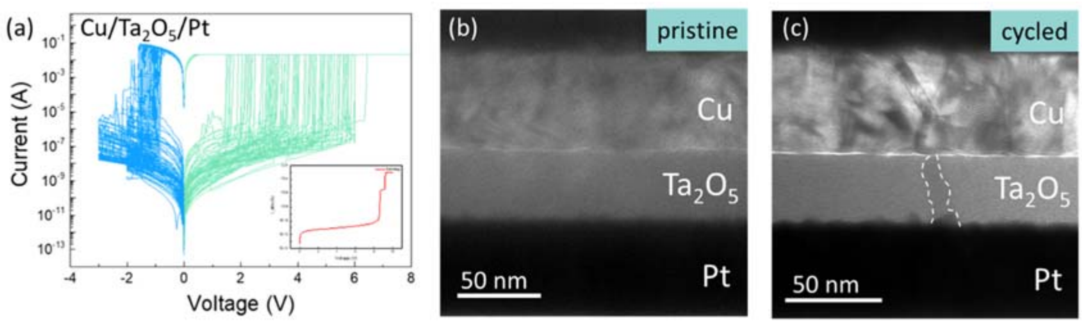

Figure 1. I-V measurement and TEM observation of RRAM devices.

In-situ Investigation of Conversion Behavior in Cu-Zn Alloy System at Atomic Scale

Yu-Lien Wu(吳昱璉) [1], Chih-Yang Huang(黃智揚) [1], Hung-Yang Lo(羅宏洋) [1] and Wen-Wei Wu (吳文偉)[1*]

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The alloy of copper and zinc has been widely used in numerous application due to its outstanding properties, such as superior electrical and thermal conductivities, antibacterial property and improved hardness and strength compared to pure copper. To explore the development of brass, the study of microstructural evolution is essential. In this work, the formation of brass and the conversion behaviors at atomic scale through diffusional reaction was investigated via *in-situ* transmission electron microscope (TEM). Copper and zinc thin films were annealed at 423K to obtain CuZn intermetallic compounds by solid-state diffusion. The HRTEM results and the corresponding FFT-DPs demonstrated CuZn and Cu have an epitaxial relationship, which could be described as $(01\bar{1})_{CuZn}$ // $(11\bar{1})_{Cu}$ and $[100]_{CuZn}$ // $[011]_{Cu}$ [1]. Furthermore, the Cu_3Zn phase transformed from order structure to disorder at the temperature of 573K in the purpose of decreasing the Gibbs free energy. Additionally, nanotwinned Cu_3Zn restricting the migration of atoms was observed, which could be applied to improve the thermal stability [2]. This study provides a direct way for in-depth understanding of metal alloys and compounds in solid-state reaction.

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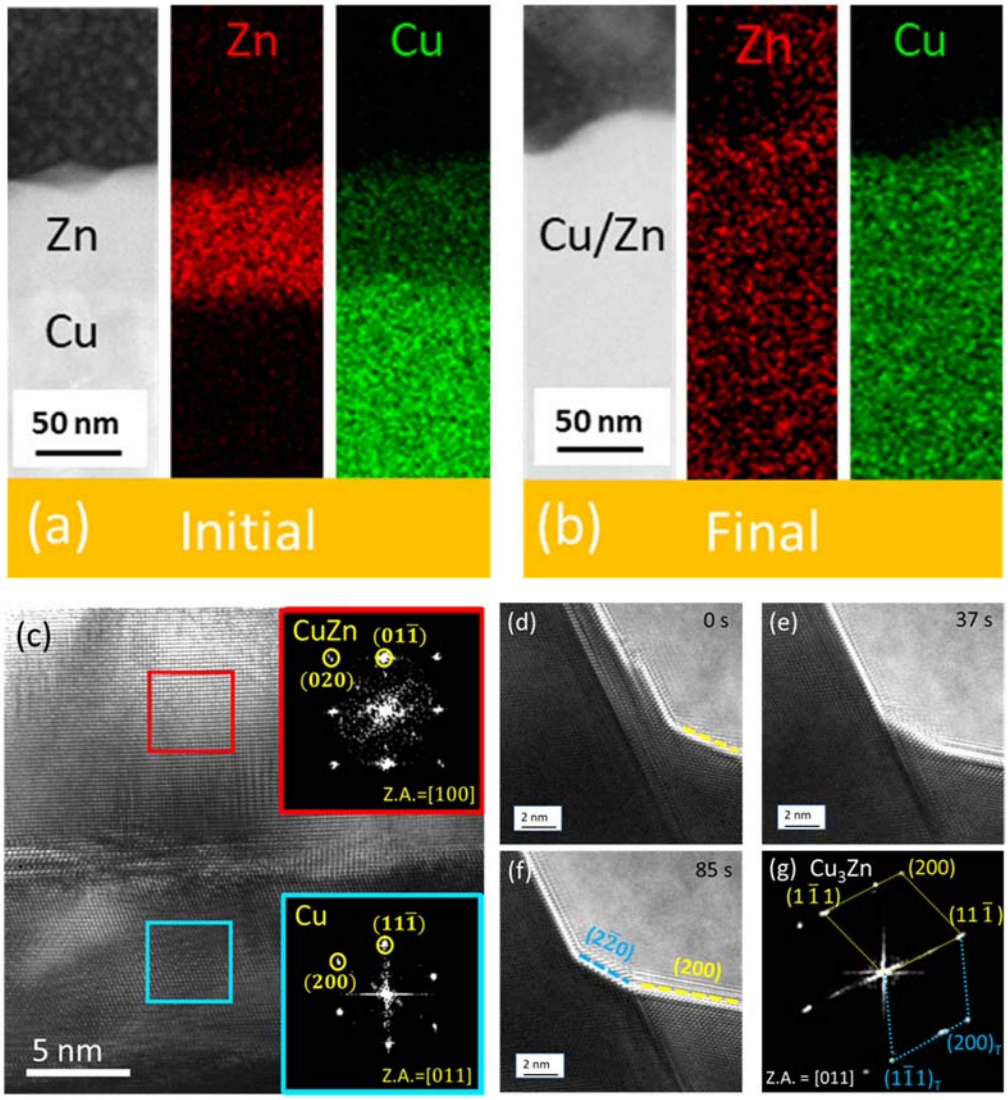

Figure 1. STEM, EDS mapping and HRTEM analysis of Cu-Zn thin film.

The Development of Graphical User Interface of The Machine Learning Based kMLLS Clustering

Ren-Fong Cai (蔡任豐) [1*], Mu-Tung Chang (張睦東)[1], Chien-Chun Chen (陳健群)[2] and Shen-Chuan Lo (羅聖全)[1]

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To discover the hidden information from data, machine learning is becoming one of the popular topics in many fields[1]. Recently, the kMLLS clustering, which combines the advantages of k-means clustering and multiple linear least square fitting, was proposed to extract endmembers from an EELS spectrum image unsupervisedly[2]. In this study, we present the development of the graphical user interface (GUI) of the kMLLS clustering routine. With the use of the GUI application, researchers can easily obtain the main components in the region of interest without prior knowledge. The results also shows the great potential to provide a significant insight into materials.

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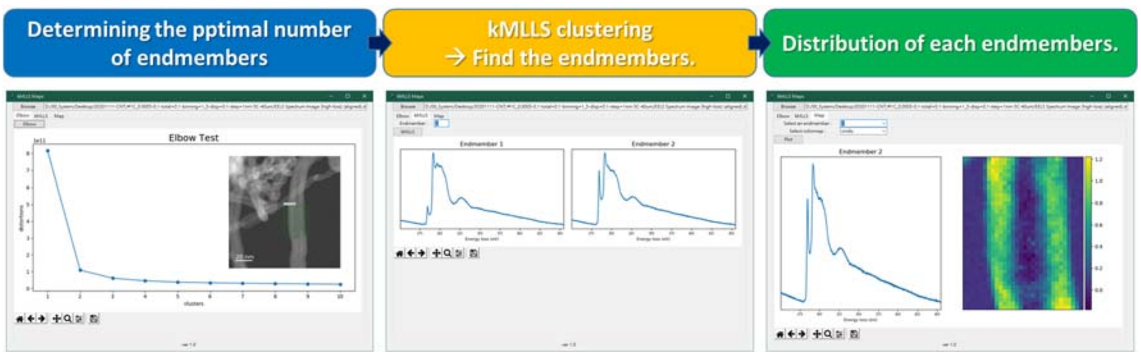

Figure 1. GUI interface of kMLLS clustering.

Photocatalytic Hydrogen Production with Ultrahigh Efficiency by Employing Large-Area MoS_2 Thin Film

Yu-Hsien Wu（吳昱賢）[1,2*], Yu-Sheng Huang（黃鈺昇）[2], Lih-Juann Chen（陳力俊）[2,3], and Yi-Chia Chou（周苡嘉）[1]

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Global warming is worsening in recent years with the increase in CO_2 emission. Finding alternative energy to the energy generated by fossil fuels becomes urgent for human society. Hydrogen production, a clean and renewable method to generate energy, has gained increasing attention.

Photocatalytic water splitting ($2H_2O \rightarrow 2H_2 + O_2$) is a significant way to produce hydrogen. Photocatalysts play important roles in the conversion of solar energy to electrical energy or chemical energy during the processing of photocatalytic water splitting. Molybdenum disulfide (MoS_2), a layered transition metal dichalcogenide, is the material which we choose as photocatalyst.

In this report, we focus on the hydrogen production performance of MoS_2 thin films with different processing parameters, including angular speeds of spinning and types of substrate. MoS_2 thin films not only have excellent performance but also are suitable for large-area production and convenient to be recycled. In addition, MoS_2 thin films have good adhesion property as well. Large-area MoS_2 thin films produced with appropriate conditions were found to have extraordinary performance in hydrogen production, achieving a rate of 1700 $mmol \cdot g^{-1} \cdot h^{-1}$.

A Novel Microchip Technique for Quickly Identifying Nanogranules in an Aqueous Solution by Transmission Electron Microscopy: Imaging of Platelet Granules

Nguyen Thi Thu Trang [1], Jungshan Chang [1], Wei-An Chen [1], Chih-Chun Chen [1], Hui-Min Chen [1], Chao-Chien Chang [2], Tsorng-Harn Fong [1] and Hsin-Pei Chiang [3] *

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In this study, a novel microchip (K-kit) was used as a specimen kit for in-situ imaging of human platelet granules in an aqueous solution using a transmission electron microscope. This microchip enabled us to observe the native human platelet granules in aqueous solution very quickly and easily. We used this microchip to identify the native platelet granules by negative staining. Furthermore, we used this microchip to perform immunoelectron microscopy and successfully label α-granules of platelets with the anti-P-selectin antibody. These results demonstrate that the novel microchip can provide researchers with faster and better choices when using a transmission electron microscope to examine nanogranules of biological specimens in aqueous conditions.

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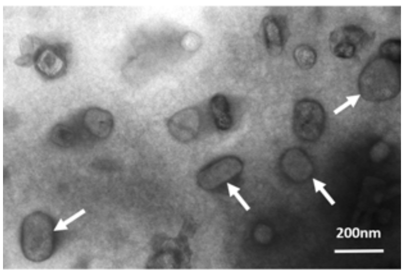

Fig.1 Negative staining electron micrographs of isolated platelet granules in the microchip.

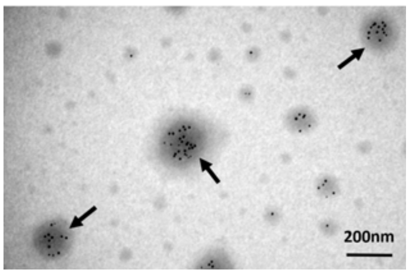

Fig.2 Immunoelectron micrographs of the gold labeled α-granules in the microchip.

液態電子顯微鏡觀測應用的低對比生物樣品負染製備技術

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電子顯微鏡對於生物分子學及奈米醫藥等領域迄今仍未獲得普及應用之原因，主要在於生物樣品大多是由有機輕元素所組成，並且含水量極高、或是為液態形式。受限於電子顯微鏡腔體內的高真空環境，多數生物樣品在觀測時只能處於結構塌陷失真的乾燥狀態，並且某些特定樣品例如脂質體(Liposomes)、或外泌體(Exosome)等，礙於本身結構組成之影響，其電子顯微鏡的影像對比度也極低，難以直接獲得良好的觀察結果。

為實現液態生物樣品可於電子顯微鏡內觀測之目的，必須設法將溶液樣品與設備腔體內的真空環境作隔絕，此最常見之作法是採用所謂的液態樣品槽(Wet Cell)來承載並觀測溶液樣品。本研究採用市售之液態樣品槽產品 K-kit 作測試，藉由適當控制其載入液層厚度、並搭配金屬負染技術，成功地實現了包括脂質體、膠原蛋白(Collagen)與血小板微顆粒(PMP; Platelet-derived Microparticles)等低對比液態樣品的電子顯微鏡影像觀察。

針對液態樣品的電子顯微鏡影像分析，目前大多仍使用銅網於乾燥狀態下觀察、或是採用昂貴複雜的冷凍電子顯微鏡(Cryo-EM)技術。而本研究提出之創新方法，由於溶液妥善密封於 K-kit 內，觀測時不會因乾燥作用使得粒子結構塌陷失真、或相互聚集堆疊。同時，經由獨特的液態負染處理，其也可達到媲美冷凍電子顯微鏡影像品質之清晰度。藉由本研究所開發之 K-kit 應用技術，可成功觀測溶液內奈米顆粒的組成、尺寸、濃度、以及群聚與團聚等結果，實現便利快速的液態生物樣品電子顯微鏡影像分析目的。

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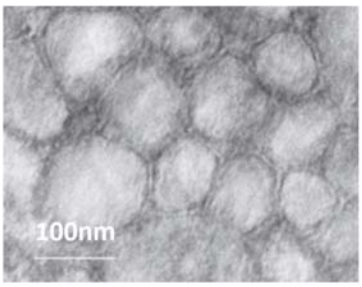

Figure 1. 利用 K-kit 負染技術於液態下觀測脂質體粒子的電子顯微鏡影像。

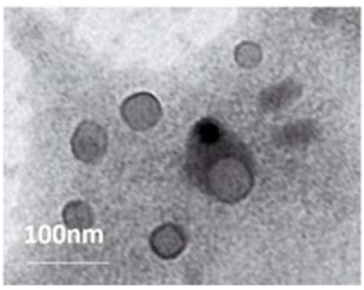

Figure 2. 利用 K-kit 負染技術於液態下觀測血小板微顆粒的電子顯微鏡影像。

The structural and properties of ZnO nanowires/Ta_2O_5 RRAM device

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RRAM has drawn major attention due to its simple metal- insulator-metal (MIM) structure and low power consumption superiority. The design of RRAM integration to large-scale array with peripheral circuits has been discussed in much research. However, in such high-density architecture, there exists crosstalk issues which leakage current flow into the unselected cells and cause the misreading. In this work, a novel 1D1R device was fabricated and the cor- responding switching mechanism was discussed. The homojunction interface in the ZnO nanowire contained an asymmetric barrier, which restricted the sneak flow in reverse bias. Additionally, the Ta_2O_5 thin film layer required the oxygen vacancies to form the conducting filaments during forming and set process, and the ZnO nanowires aimed to supply the oxygen vacancies source, which increased the stability of resistance switching.

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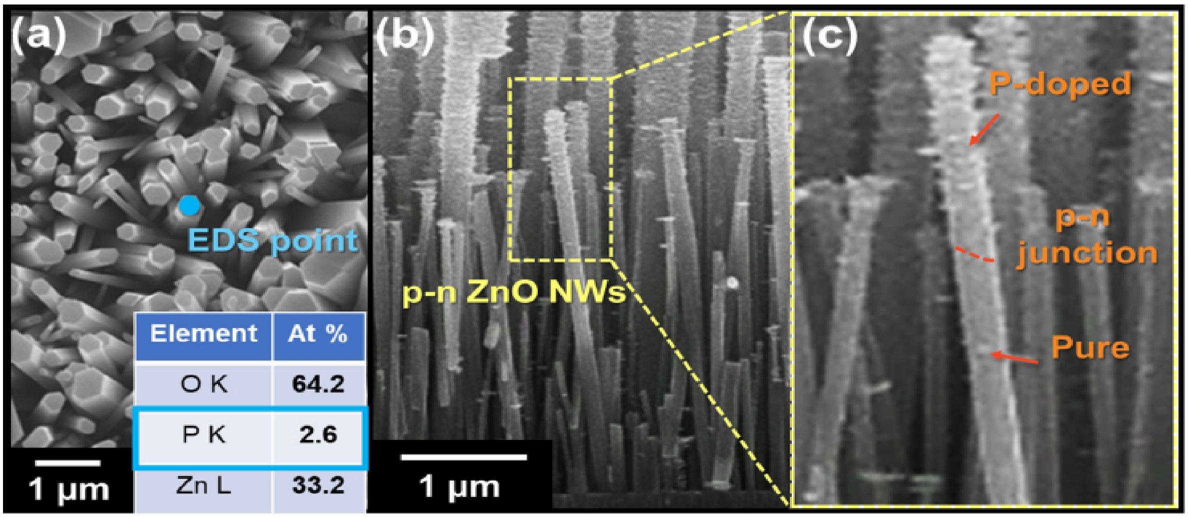

Fig. 1. The morphology images of p-n nanowires.

Precipitation and Deformation Behavior in AA6111 Al Alloy

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In this research, the precipitation and deformed behavior of AA6111 Al alloys with pre-aging heat treatment of 250℃ for 7min is investigated. After pre-aging, warm tensile tests are conducted. There are three different stain rates which are $0.001s^{-1}$, $0.01s^{-1}$ and $0.1s^{-1}$ and four different temperatures which are 25°C, 150°C, 200°C and 250°C applied on tensile test. Electron backscattered diffraction (EBSD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM) are applied to analyze the evolution of microstructures. The results show that grain size is about 25 um and there is retained stress after warm deformed through EBSD. Ductile fracture surfaces including some possibly cracked Si are observed by SEM. All TEM images are taken along <001>Al zone axis in order to observe the precipitates of β” and L phase. From dark-field images, the density and size of precipitates increase after warm deformed.

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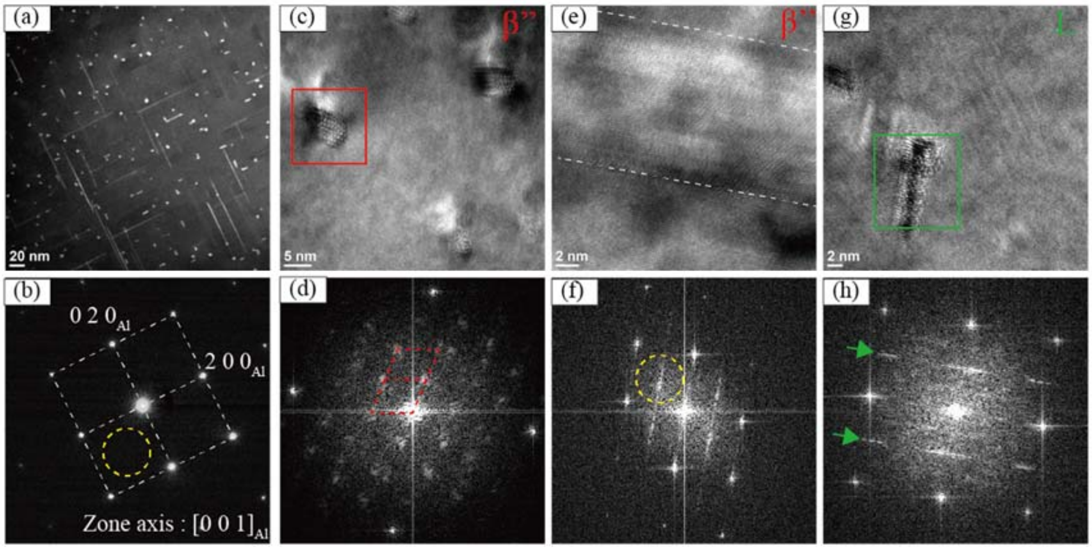

Figure 1. The TEM DF, HRTEM and FFT images of AA6111 Al alloys of 250°C 7min aging

Biocompatibility of NbTaTiVZr with Surface Modifications for Osteoblasts

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We reported a potential biomedical material, NbTaTiVZr, and the impact of surface roughness on the osteoblast culture and later behavior based on *in vitro* tests of pre-osteoblasts. In the early stage of incubation (within 7 days), rougher surfaces led to better cell adhesion, viability, and proliferation. The surface-free energy has been measured and correlated with results from cell experiments. In the later stage, once the alloy surface was covered with cells and the extracellular matrix (ECM), the impact of surface roughness on cellular behaviors diminish. Besides, NbTaTiVZr showed superior biocompatibility, compared to CP-Ti and can potentially be evaluated for clinical usage.

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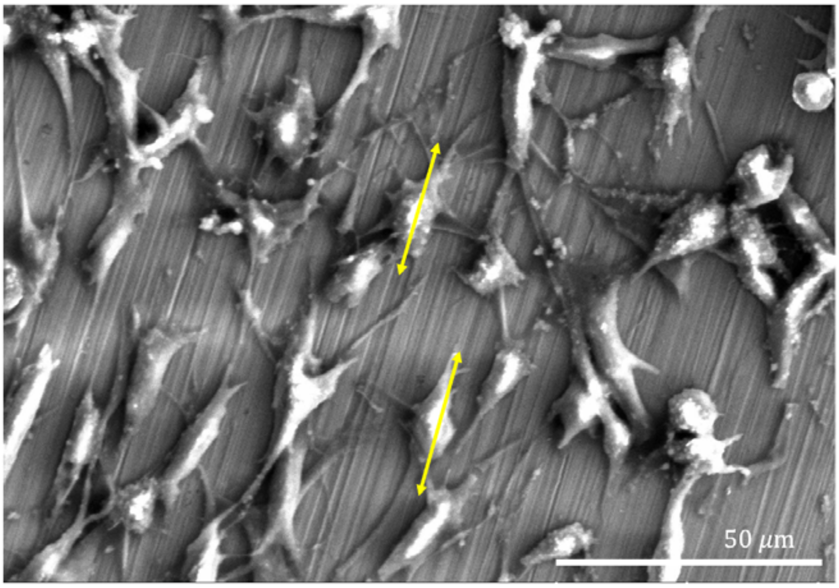

Figure 1. SEM images showing an MC3T3-E1 cell morphology after 4 h of incubation on the NbTaTiVZr alloy specimen with a surface treated using 1,200 grits sandpaper. Yellow double arrows indicated the alignment of the cellular axis and the surface grooves.

In-Situ TEM Observation of $Na_3V_2P_3O_{12}$ Growth During Calcination Process at Atomic Scale

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Solid state sodium batteries (SSSBs) are promising alternative to lithium batteries owing to abundance of sodium and can be made into large-scale application [1]. Previous study showed that synthesizing $Na_3V_2P_3O_{12}$ (NVP) on $Na_{3.4}Zr_2Si_{2.4}P_{0.6}O_{12}$ (NZSP) substrate could methodically improve the contact of the surface between positive electrode material and electrolyte. However, the detailed information of structural evolution are still lacking. In this work, the synthesis process of NVP on NZSP substrate was investigated at atomic scale by *in-situ* high resolution transmission electron microscope (HRTEM). The whole calcination process was consisting of crystallization and aggregation of NH_4VO_3 and NaH_2PO_4, and then transformed NVP. Furthermore, HRTEM videos and the corresponding FFTs even demonstrated that NVP were epitaxially grown with NH_4VO_3 and NaH_2PO_4, and the orientation relationship were $[012]_{NH4VO3}//[12\bar{1}]_{NVP}$, $(12\bar{1})_{NH4VO3}//(2\bar{1}0)_{NVP}$ and $[\bar{3}21]_{NaH2PO4}//[210]_{NVP}$, $(12\bar{1})_{NaH2PO4}//(009)_{NVP}$, respectively. In addition, the element distributions were identified by energy dispersive spectroscopy (EDS) mapping analysis. No impurity phase was obtained during calcination process, indicating outstanding thermal stability of the NVP/NZSP pellets. This study firstly reveals the formation and growth processes of NVP at atomic scale. The information provides the in-depth understanding of structure transformation during the calcination process, which could be applied for further exploration of electrode materials and developments of SSSBs.

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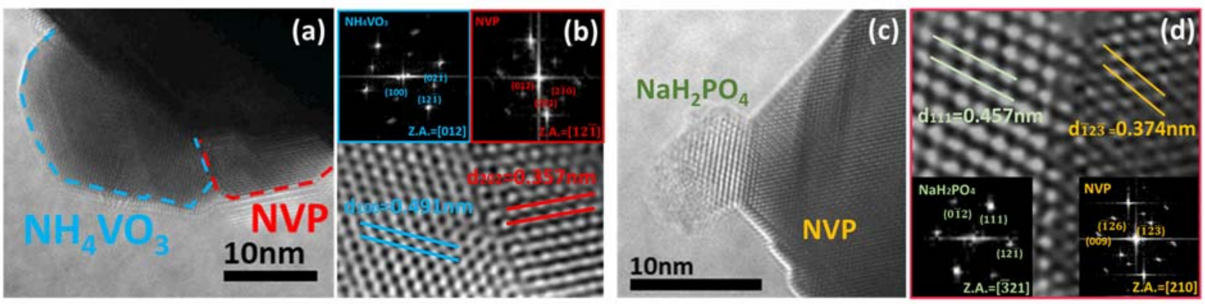

Figure 1. Epitaxial relationship of NVP with precursors NH_4VO_3 and NaH_2PO_4.

Determine Atomic Coordinates from the Reconstruction with Large Missing Wedge

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Electron Tomography is a unique technique to study 3D structures of materials at the atomic scale. Typically, it is impossible to collect projections at all angles, so-called the missing wedge problem, such that the resolution in beam direction of the 3D reconstruction is limited. Therefore, it is difficult to trace accurate coordinates of individual atoms from a distorted reconstruction. Here we combined both 2D and 3D tracing with a distance constraint to determine the coordinates of individual atoms in a reconstruction of a PtRuAu core-shell nanoparticle. The result has been demonstrated that the retrieved coordinates are more accurate than the previous approach.

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Home-made Atomic Layered Deposition with Inductively Coupled Plasma Etching System

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The thin film of Al_2O_3 was used to protect the surface of the substrate from deposited impurities. To coat a high-quality protective film on the surface, atomic layer deposition (ALD) is a promising method. Unlike the traditional processes, we built our own ALD system with inductively coupled plasma (ICP) that can generate cleaner samples under the protective film. Before depositing the Al_2O_3 thin film, we first used ICP to clean the substrate surface preventing impurities from being covered below the film. In this study, we report the changes with different ICP etching rates as well as the corresponding scanning transmission electron microscope (STEM) images of Al_2O_3 coated samples. We demonstrate that the STEM images of coated samples provide a higher contrast.

Strengthen mechanical property of A novel FeMnCoCrNiSi Medium entropy alloy by deformation induced FCC to HCP phase transformation

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High entropy alloy (HEA) or Medium entropy alloy (MEA) have attracted extraordinary attention since the single faced-center-cubic (FCC) Cantor alloy with excellent mechanical properties in a cryogenic environment was observed.[1][2] Based on the cantor alloy, equal-atomic CoCrFeMnNi, Nemours Cantor-like alloy systems have been widely studied in the past decade. Adding external elements and adjusting operational element contents, all of the alloy design strategies were to enhance the mechanical performance through different strengthen mechanism. In this work, a FeMnSi-based MEA containing 10% Cobalt, 12.5% Chromium and 5% Nickel (at atomic%) was achieved to be a single FCC crystal structure through vacuum argon melting furnace, and it is realized the improvement in the mechanical properties through tensile test comparing with those of Cantor alloy. By reduction of valuable contents, such as cobalt and nickel, the cost of the novel MEA has been cheapened, and the addition of Silicon into this system has diminished the stacking fault energy (SFE) in order to trigger the deform-induced e martensite phase transformation over a tensile test. Under the transmission electron micrograph (TEM) observation, various hexagonal close-packed (HCP) martensite phases were investigated among the deformed microstructure. The result from cryogenic tensile under the liquid nitrogen environment illustrated two series of interwoven e martensite phase that behave both slat-shaped and needle-shaped sizes, which contribute the ultimate tensile strength (UTS) to a value over 1.2GPa. To further study the effect of microstructure evolution on the mechanical property among the elongation process, X-ray diffraction (XRD), electron backscatter diffraction (EBSD) technique have applied in this work.

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Abnormal Hall-Petch Constant in High-Entropy Steel

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The Hall-Petch effect of an high entropy steel (HES) consisting of Fe-Mn-Al-Si-C-Mo-V was investigated. The grain sizes were controlled by annealing at 1030°C for 10 min, 15 min, 1 hr, 4 hr, and 16 hr after cold rolling for 85% reduction in thickness. The relationship between grain sizes and yield strength fit well to the Hall-Petch equation. Besides, the Hall-Petch constant, σ_0, of this steel is 353 MPa, and k is 673 MPa·$\mu m^{0.5}$ (twin boundaries considered as grain boundaries), which are both far larger than other FCC-type steels. The reasons are concluded as follows. First, the high frictional stress value is attributed to the high alloying degree of the HES, which gives rise to the severe lattice distortion due to the large deviation of the atomic radius. In addition, short-range ordering existed after water quenching. As for the k value, the preference of interstitial atoms, carbon, to segregate to the grain boundaries makes grain boundaries be able to strongly block the dislocations. Besides, the slip mode of dislocations also affects k value. The stacking fault energy of the HES is about 49.5 mJ/m^2, resulting in planar slip mode, which has lower mean free path than that of cross slip mode. Therefore, the grain size sensitivity, k, is raised.

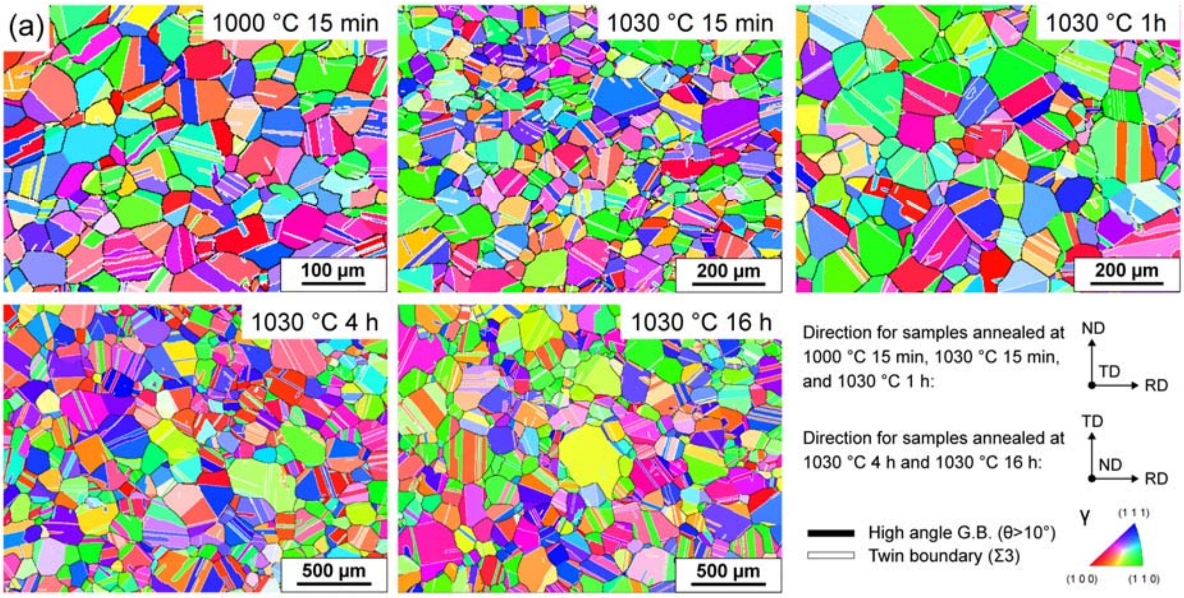

Figure 1 Electron back scattered diffraction analysis showing inverse pole figure-Z on samples after different heat treatment. All are fully austenitic.

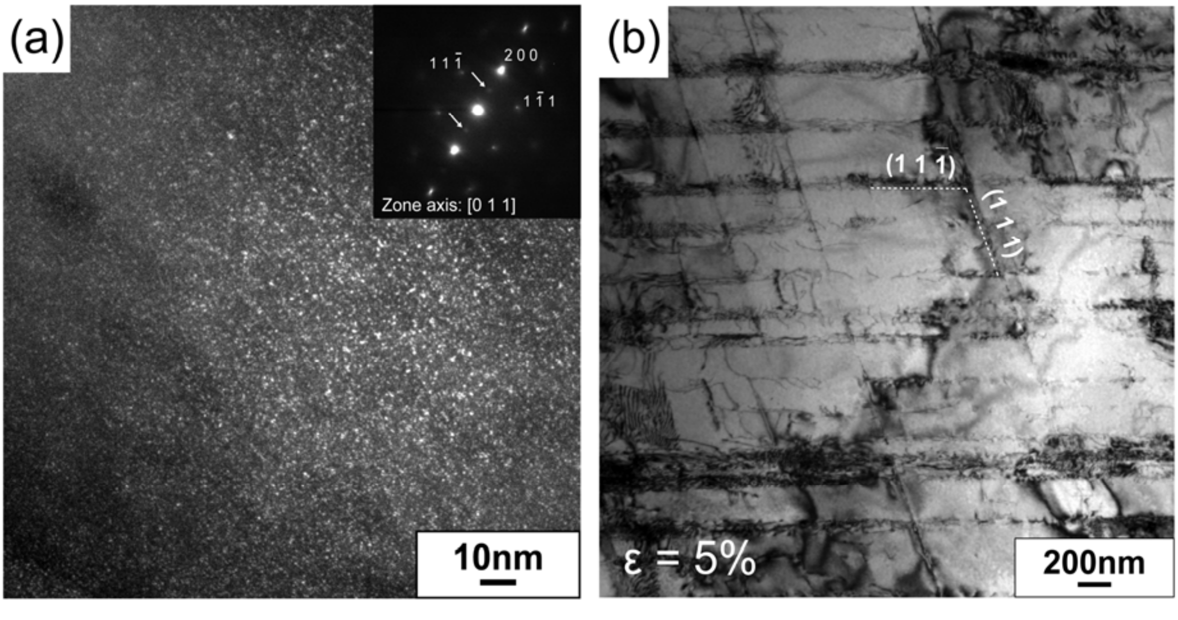

Figure 2 TEM micrographs showing (a) Short-range ordering in as-quenched sample, and (b) Dislocation planar slip at 5% of engineering strain.

Lattice Distortion and Atomic Ordering of the Sigma Precipitates in CoCrFeNiMo High-Entropy Alloy

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The equiatomic CoCrFeNiM (M: different types of metals) is currently considered as a model system in high-entropy alloys (HEAs).[1] We study the lattice distortion of σ-phase precipitation in CoCrFeNiMo HEAs by several methods. The HAADF STEM image shows the atomic distortion and the variation is calculated to be approximately 2.9%. Nevertheless, lattice distortion value calculated from atomic size difference is about ~9.9%. In addition, we used EELS elemental mappings to identify the compositional distributions, we found that 8j sites have Mo, Fe, Co, and Cr signals but no Ni signal (**Figure 1**). Our findings provide the evidences of the lattice distortion and the partially-ordered σ-phase in CoCrFeNiMo.[2]

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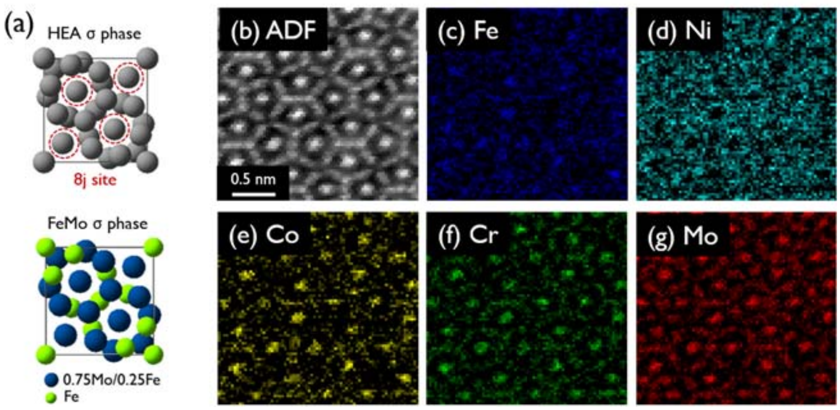

Figure 1. (a) Crystal mode of 8j site. (b-g) HAADF STEM atomic image, the corresponding atomic EELS mappings of Fe, Ni, Co, Cr, and Mo, respectively.

Synthesis of CeO_2@TiO_2 hollow core-shell structure with enhanced photocatalytic performance

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CeO_2@TiO_2 hollow core-shell structure was synthesized by a two-step method. Spray pyrolysis process was applied to prepare hollow CeO_2 microspheres first and anatase TiO_2 nanoparticles were deopsited by sol-gel method. XRD and TEM were used to investigate crystal structure and morphology. Optical properties and measurement of photocatalyst performance were carried out by UV and PL. The results demonstrated that CeO_2@TiO_2 hollow core-shell structure was synthesized successfully withour any impurities and TiO_2 shell thickness can be modified by tunung Ti/Ce ratio of the precursor. UV and PL tell that after forming core-shell structure, band gap was reduced and the life time of photoinduced electron-hole pairs were prolonged. Photodegradation by CeO_2@TiO_2 hollow core-shell structure with different Ti/Ce ratio was a pseudo first-order reaction under both UV and visible light with $K = 0.1$ and 0.023.

Micro-scale TiO_2 hollow sphere and its physical properties

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In order to study the morphology effect on TiO_2 physical properties and provide a novel material, hollow TiO_2 spheres was synthesized successfully using carbon spheres as template. Carbons spheres were prepared hydrothermally and the deposition of TiO_2 shell was carried out by sol-gel method. Shell thickness was controlled by adding different amout of Ti precursor (TTIP). TEM images revealed that the sehll was discrete and was composed of TiO_2 nanoparticles. Diffraction analysis showed that only anatase phase appeared without any other phases. Based on dark field analysis, TiO_2 nanoparticles was found to be well crystallized with the size of 15 nm. X-ray absorption spectrum demonstrated that the amount of Ti^{3+} was increased with increasing the shell thickness, which was attributed to the incomplete oxidation during annealing porcess. UV-vis spectrum results showed that band gap reduced from 3.5 eV to 3.3 eV when shell thickness increased from 15.6 nm to 85.1 nm, which is consistent with the observation of XAS analysis. As for the magnetic properties, TiO_2 hollow spheres were found to be ferromagnetic at room temperature, the value of saturation magnetization reaches 0.015 emu/g.

Characterizations on ZK60 Mg Alloy for Hydrogen Storage

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ZK60 Mg alloy, providing a capacity of over 5.0 wt. % and releasing temperature below 300 °C has been used as energy materials for hydrogen storage. In this work, the microstructural evolution from as-extruded materials (Figure 1) to ball-milled materials (Figure 2) was investigated by using electron backscattered diffraction and transmission electron microscopy. The correlation between microstructure and hydrogen storage was further studied by using thermal desorption analysis. It was found that fine grains in as-extruded ZK60 Mg alloy can be refined into ultrafine-grained powders. Moreover, Zr-riched precipitates can retain in the final powder. Such novel microstructure of ball-milled powder could explain the multiple desorption behaviors. The microstructural results address a pathway to optimize performance of hydrogen-storage alloy by microstructural design.

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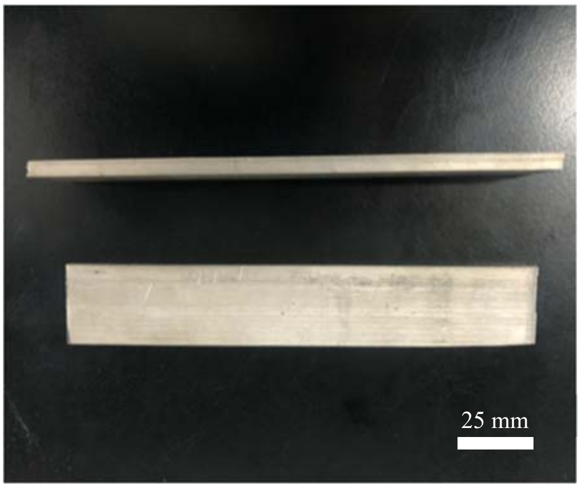

Figure 1. as-extruded ZK60 Mg specimen size: 2.5*0.5*15.0 (cm)

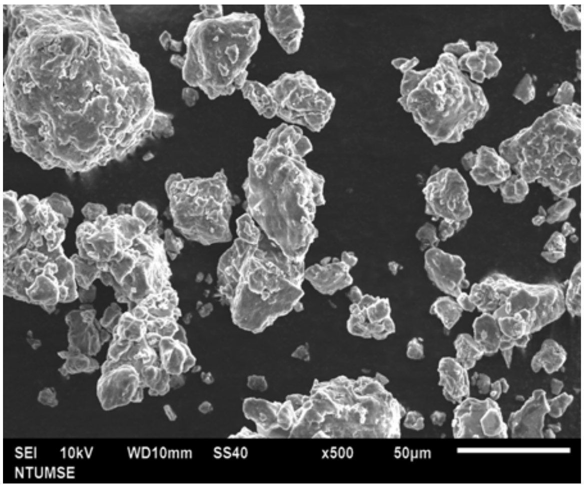

Figure 2. SEM image of ball-milled ZK60 powder with graphene oxide

Scanning Transmission Electron Microscopy on the Interface between TiN and Si

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Conducting TiN as metal gate and barrier is a critical material in semiconductor devices for which the interface may have an effect on the device performance. Here, evolution of the TiN/Si interfacial structure in as-deposited condition after reactive sputtering deposition and post-annealed condition is investigated by S/TEM. Epitaxial TiN films were grown on Si (100) substrate at temperature above 750°C, while annealing was done at 1050°C. The HAADF (High angled annular dark field) STEM images show that the TiN film in the as-deposited condition is mainly in direct contact with Si at the interface with some local disordered regions in a size of a few nanometers which can be shown to be composed of Ti-Si-N (Fig. 1). Annealing results in significant increase of the disordered regions due to the interdiffusion of Si and Ti (Fig. 2).

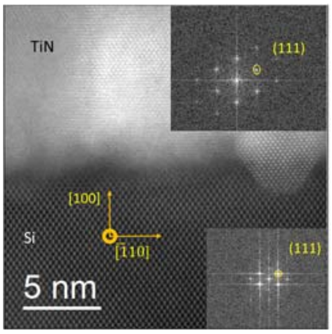

Figure 1. STEM ADF image in as-deposited condition.

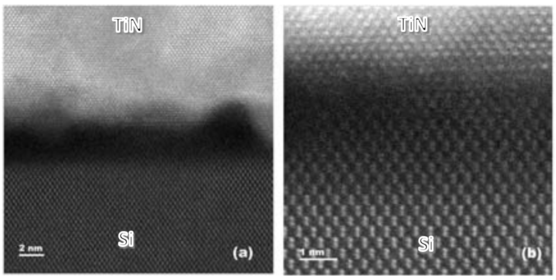

Figure 2. STEM ADF image in annealed condition.

An Investigation of Different Ageing Treatments in AA7050 Al Alloys

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In this study, the high strength AA7075 aluminium alloys, combining with proper Cu and Mn content, are subjected to different ageing treatments such as one-step ageing treatments, two-step ageing treatments, and retrogression and re-aging treatments, accompanying with variable degree of deformation, for molding the industrial processes (i.e., warm forming and hot stamping processes). During the ageing treatment, the nano-scaled microstructural evolution of precipitates such as GP zones, η' precipitates, and η precipitates are characterized by Transmission electron microscope (TEM) and High resolution transmission electron microscope (HRTEM). Furthermore, the size, morphology, and volume fraction of precipitates could be quantified by Small angle X-ray scattering (SAXS). Therefore, it is a good chance to construct the microstructural evolution of precipitates related to different ageing treatments for improving mechanical properties of the high strength 7xxx series aluminium alloys in the automobile industry.

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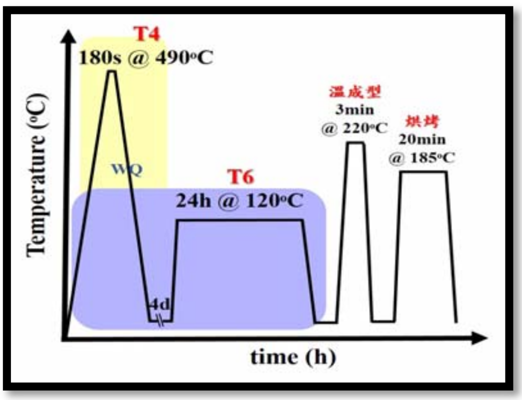

Figure 1. Simulation of heat treatment for molding the industrial processes.

Differences in Microstructure between Martensite and Bainite in an Ultra-low carbon steel

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An ultra-low carbon steel was studied in this work. The heat treatment contained various cooling rates to investigate the microstructure evolution. Massive ferrite formed at low cooling rate and was characterized by irregular grain boundaries and high density of dislocations within a grain. Bainite formed at low to middle cooling rates and could be characterized by the sheaf-like morphology. Martensite formed at high cooling rate and could be characterized by the lath morphology and the hierarchical structure. Three different phases could also be characterized by vickers hardness test.

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Direct structure-determination of nodavirus in solution by small-angle x-ray diffraction microscopy

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The structures of biological macromolecules are usually obtained from crystallography and cryo-electron microscopy. The requirements of sample preparation limit the understanding of their original state. Small-angle x-ray scattering (SAXS) is able to obtain structural information from biological samples in solution. However, analyzing the structure from the obtained one-dimensional(1D) data requires prior knowledge of the sample and cannot guarantee a unique solution. Coherent diffraction imaging (CDI) provides excellent uniqueness in 2D/3D phase retrieval while the resolution is limited by the poor signal-to-noise ratio during high-angle scattering. Here, we combine CDI and SAXS to directly image a 19-nm-sized nodavirus particle in solution at a 1.3 nm pixel resolution. 77,170 diffraction patterns are summarized from randomly distributed nodavirus particles. Without prior knowledge, the core-shell structure can be obtained from the diffraction intensity alone. The hollow density distribution of nodavirus particles revealed by our reconstruction is consistent with the structure determination from crystallography and cryo-electron microscopy. We believe that this work represents a new protocol for characterizing the structures of macromolecules in solution from small-angle x-ray scattering data.

Diffusion behaviors of Ni in ZnO nanowire observed by in-situ transmission electron microscopy

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ZnO has wide band gap (3.37 eV) and high exciton binding energy (60 meV), thus, it can be used for the application in solar cell, photocatalysis, and electric devices.[1] Owing to the development of transmission electron microscopy (TEM), in-situ study is capable to clarify the mechanisms of the reaction between materials. The study on the ZnO-based heterostructures is popular recently, since it provides fast ion diffusion and electron transfer.[2] in-situ study is intended to observe the formation of heterostructures.[3] Therefore, we use in-situ observation to understand the diffusion phenomenon of Ni in ZnO nanowires (NWs). The snapshot of Ni diffusion in ZnO NW is showed in **figure 1.** which indicates that Ni diffuses along [001] of ZnO NW.

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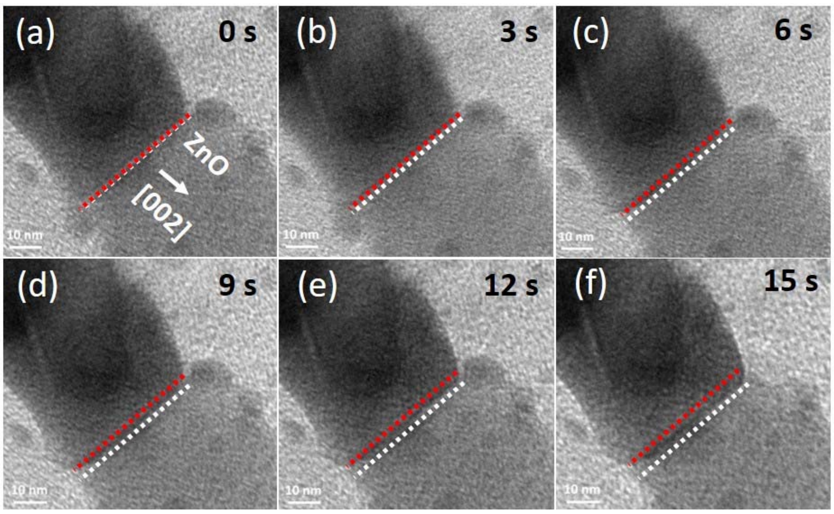

Figure 1. Snapshots exhibit layer-by-layer diffusion of Ni in ZnO nanowire.

STEM Image Stitching for Extending the Field of View

Chin-Ying Chou(周晶瑩) [1*] , Ying Chen(陳穎) [1*], Chien-Chun Chen(陳健群) [1*]
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Scanning transmission electron microscopy (STEM) has wide applications in materials sciences. The trade-off of a high-resolution image is usually a limited field of view due to the size of detector. Here we have developed an image-stitching approach to overcome the aforementioned issue. By combining images of same positions at different magnifications and of different positions at a high magnification, we are able to generate atomic resolution STEM images of a high-entropy-alloy needle with a diameter around 80 nm.

Microstructure Evolution of FeCoNiCr High-entropy Alloy at Room Temperature

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Split Hopkinson pressure bar (SHPB) experiments were conducted to investigate the mechanical behavior and microstructure of FeCoNiCr alloy under the strain rate of 7000 s-1 and room temperature. The results indicate that the true stress will be higher with higher strain rate. The corresponding deformed samples were studied mainly by TEM and EBSD, with the focus on deformation twins. Nano deformation twin was prevalent at the condition of small grain and large grain, two variant twins in material could be found, such as deformation twin in annealing twin.

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Impact of increasing Ag:Mg weight ratio on the Ω-phase coarsening resistance of strengthened Al-5.1Cu-1.0Mg alloys

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2000 系列鋁合金具有比強度高、抗疲勞性佳等特性，已經被廣泛使用在航太領域中。在 AA2014(Al-Cu-Mg)鋁合金中，其析出物演化為:過飽和固溶體 → GP Zone → θ″ → θ′ → θ(Al_2Cu)平衡相[1]以及過飽和固溶體 → Cu-Mg cluster → GPB Zone → S″/GPB2 → S′ → S(Al_2CuMg)平衡相[2]。其中 θ′與 S′並非熱穩定相，容易於過時效處理中轉變為 θ、S 平衡相並粗化，導致強度下降，因此無法同時兼顧強度與抗應力腐蝕性。本研究探討了於 Al-Cu-Mg 中添加少量 Ag 之 AA2040(Al-Cu-Mg-Ag) 鋁合金，其對於顯微結構與機械性質之影響，並藉由高解析電子顯微鏡(HRTEM)分析 θ′與 Ω 之形貌、使用小角度散射(SAXS)定量分析析出物之平均大小與分布。研究結果顯示在 T6 頂時效(peak ageing)中，添加 Ag 之 AA2040 鋁合金強度大幅提升。藉由 HRTEM 分析顯微結構與 SAXS 定量分析可得知 AA2040 鋁合金於 T6、T7 過時效(over ageing)與 ageing 100 小時中 Ω 相分布皆均勻且厚度差異不大，因此在犧牲少許韌性之情況下能夠大幅提升材料之強度與抗高溫潛變性。

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Investigating Multiple Twinning Relationships in FCC Crystal by Electron Backscatter Diffraction Analysis

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Scanning electron microscopy (SEM) equipped EBSD (Electron Backscatter Diffraction) detector has been intentioned to researchers in recent years. The advantage of this technique is that information of the crystal orientation can be quickly acquired. It is well known that the twinning relationship of FCC (face centered cubic) crystals is 60 degrees along the <111> direction. In addition to the first twinning relationship, are there any chances of having a second twinning relationship or even a third twinning relationship or more? The answer is yes. We also use mathematical matrices to understand these orientation relationships. In this study, we used 316L stainless steel (Fig.1) as the target for the orientation relationship research.

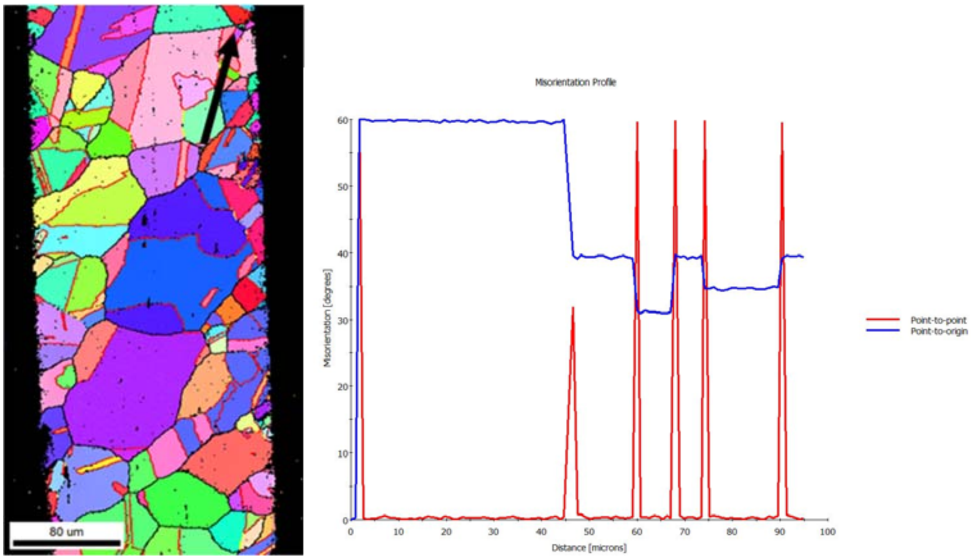

Fig.1 The EBSD result of 316L in 1200°C 3 days. The misorientation profile can let us understand the misorientation relationship between the all mapping data.

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Mechanical Property and Microstructure of Low-stain-rate Tensile Deformation in the FeCoNiCr Quaternary High-entropy Alloy

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In this study, we observed the Fe-Co-Ni-Cr quaternary high-entropy alloy material with 70% cold-rolled and then annealed it at relatively low temperature (650°C). We observed the growth situation of the annealing twins after annealing at different time from 10 minutes to 4 hours. In addition to the annealing twins in the annealing process within four hours, there are large grains which have not been recrystallized in the original cold rolling process, and these large grains have deformation twins generated during cold rolling. In the low strain rate tensile test, the results show that the partially recrystallized tensile specimens have better strength than fully recrystallized tensile specimens because the deformation twins which were contained in the original cold-rolled grains can impede the dislocations movement but sacrifice some ductility.

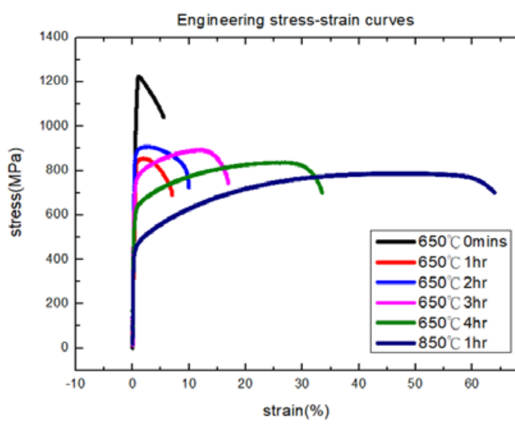

Figure 1. Engineering stress-strain curves.

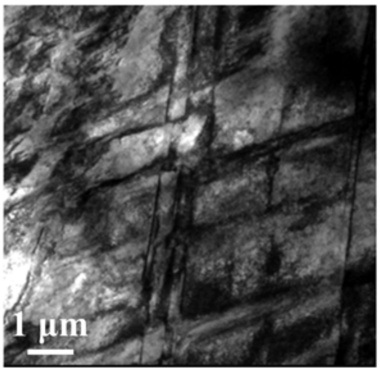

Figure 2. TEM result of Tensile specimen after 1 hour@650°C, deformation twins, and many dislocations can be observed.

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Annealing-Induced Abnormal Hardening in Cold Rolled CoCrNi Medium Entropy Alloy

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A CoCrNi equiatomic single solid solution medium entropy alloy (MEA) was cold rolled with a thickness reduction of ~70% at room temperature, followed by annealing treatment with relatively low temperature. Annealing-induced abnormal hardening and partially recrystallized structures were observed after annealing treatment at 973 K. Low-temperature annealing treatment also produces a large number of nano twins which increase strength and ductility simultaneously. EBSD and TEM analysis were used to investigate microstructure.

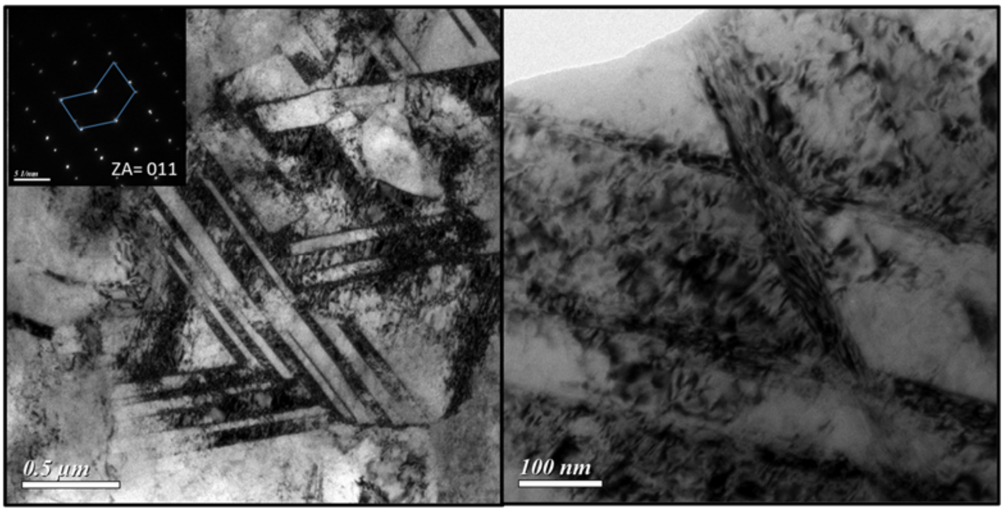

Fig.1 700°C - 30 min. Annealing twins and Deformation twins after tensile test.

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Asynchronous ptychography using multiple CPUs

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Ptychographic iterative engine (PIE) is a scanning coherent diffraction imaging (CDI) algorithm for extended objects. Overlapping illumination areas on the sample is the prerequisite to perform the reconstruction. Comparing to conventional CDI, Ptychography promises extended field of view and superior convergence in phase retrieval, while the general issues are the time-consuming computation and the huge storage. Here, we develop an asynchronous Ptychographic approach that significantly reduces the computational time by stitching multiple reconstructions from distributed CPU cores.

The Influence of Austenization Temperature to Microstructure of High Carbon High Alloy Tool Steel

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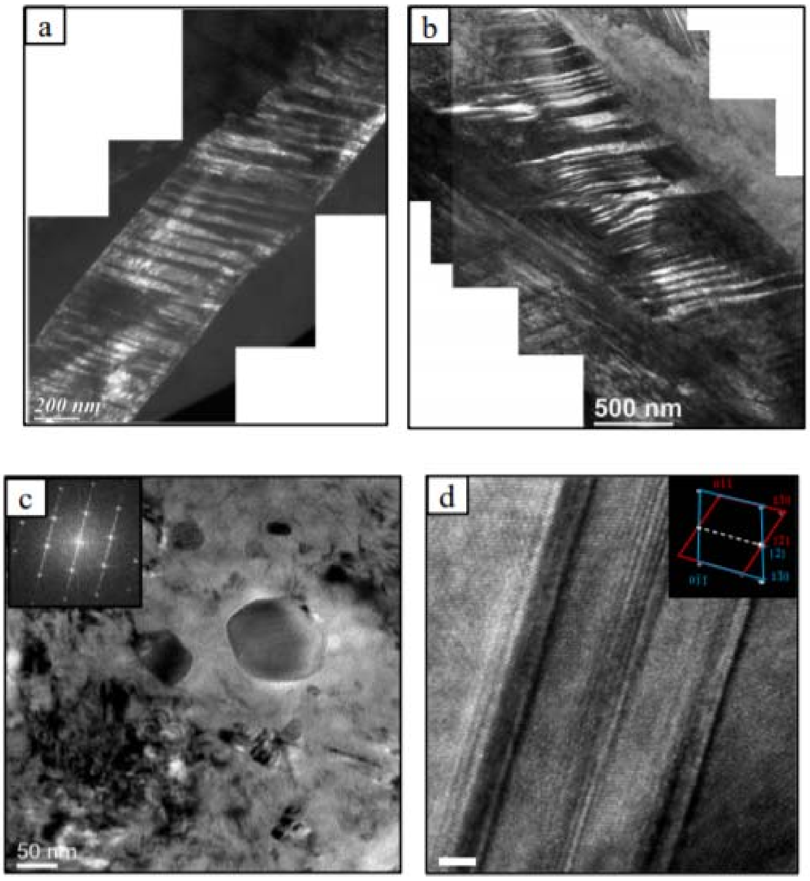
Department of Materials Science and Engineering, National Taiwan University, Taipei, Taiwan

High carbon high alloyed tool steel has great hardenability and high hardness. Austenization condition especially temperature can affect the prior austenite grain size(PAGS) and lead to different microstructure of this material that brings about different hardness. The material was subject to different austenization heat treatment with dilatometer. Microstructure was than observed with TEM. The results shows how different austenization temperature affect the hardness and martensite microstructure of tool steel.



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Composing an Abstract of the Poster Presentation for the Annual Meeting of the Microscopy Society of Taiwan

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Department of Materials Science and Engineering, National Taiwan University, Taipei, Taiwan

In this research, OM, SEM, and TEM were used to investigate lath martensite structure in low carbon steel 22MnB5. By comparing OM/SEM/EBSD/KAM images, we can clearly see the coalesce region in one retained austenite grain. From EBSD analysis, we can find a retained austenite grain in $\langle \mathbf{110} \rangle$ zone axis by using $\{001\}_{bcc}$ pole figure, and indicate different packets and variant pairs within the grain. It is interesting to note that two kinds of block(e.g. block V1-V4 and block V3-V6) appear in similar color in one packet. From TEM analysis, inter-penetrating twin can be observed between two lath.

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4. Quantitative Analysis of the Crystallographic Orientation Relationship Between the Martensite and Austenite in Quenching-Partitioning-Tempering Steels.

Development of Algorithm for LowDose CT

Huai Yu Chao (曹淮宇), [1*] and Chien Chun Chen (陳健群)[1]

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[*]hy960731@gmail.com

Computing Tomography (CT) has been widely used for 3D biological imaging. From the projections at different angles, the reconstructed CT image provides accurate diagnosis to patients without performing surgery. Conventional CT requires hundreds of projections to obtain a reliable reconstruction. The necessity of heavy dose is being questioned due to the healthy issue from long exposure. Here we propose an iterative reconstructing algorithm based on fast Fourier transform (FFT) to address this issue. We have demonstrated that our algorithm can reduce the radiation dose by an order while maintaining the correctness of reconstruction.

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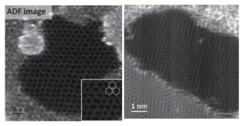

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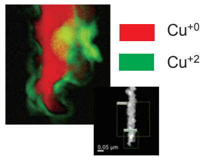

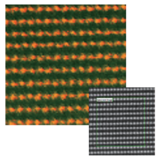

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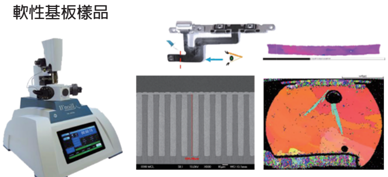

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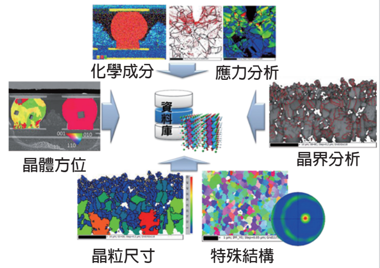

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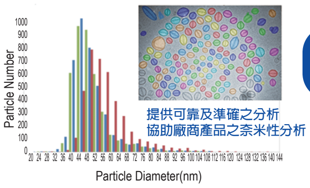

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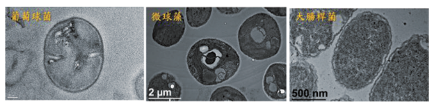

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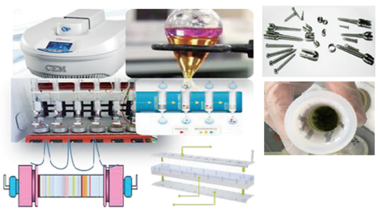

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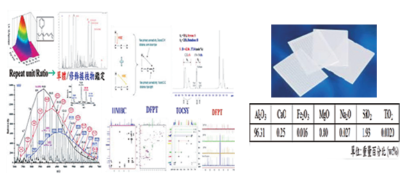

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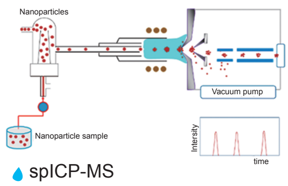

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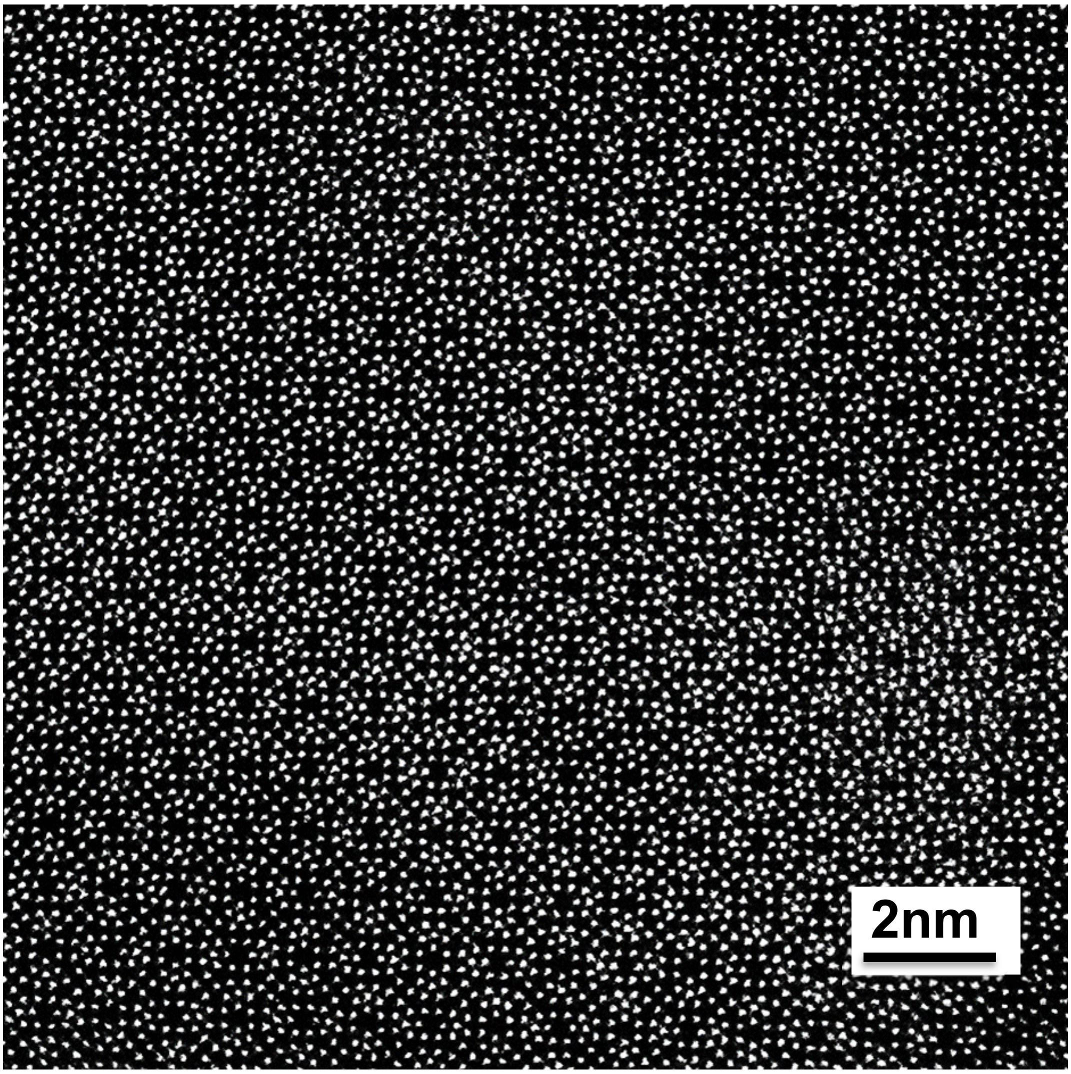
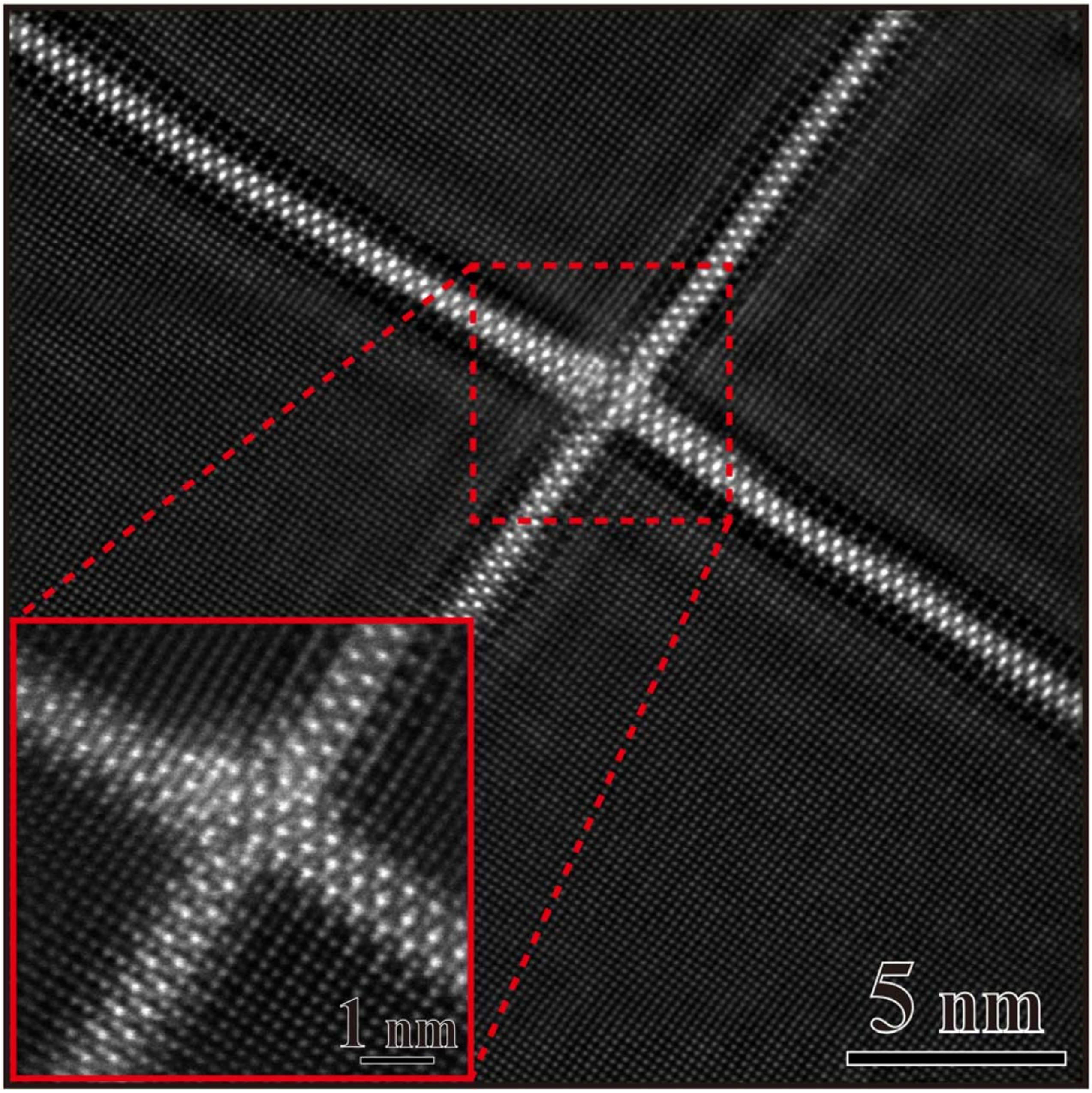
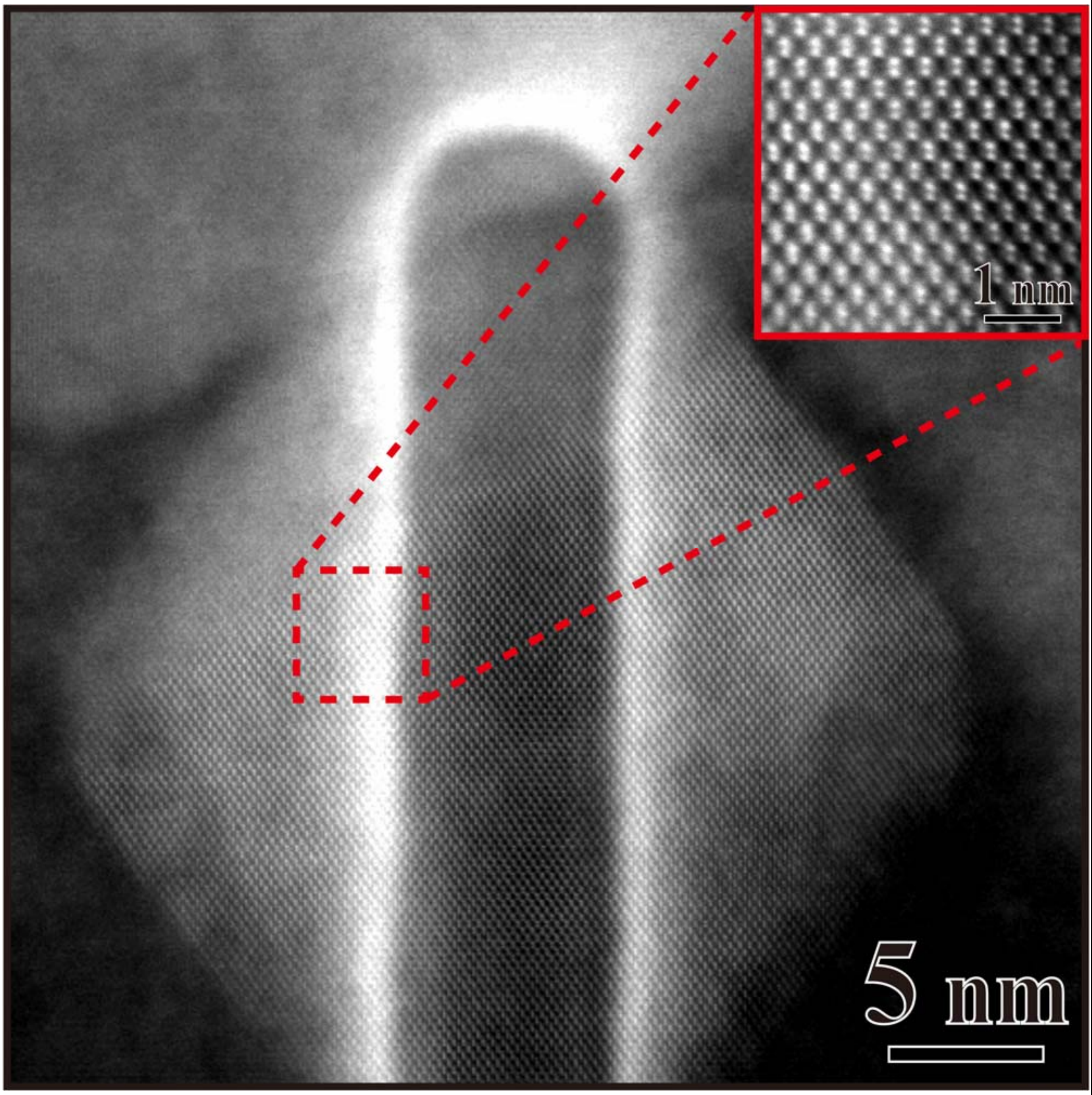


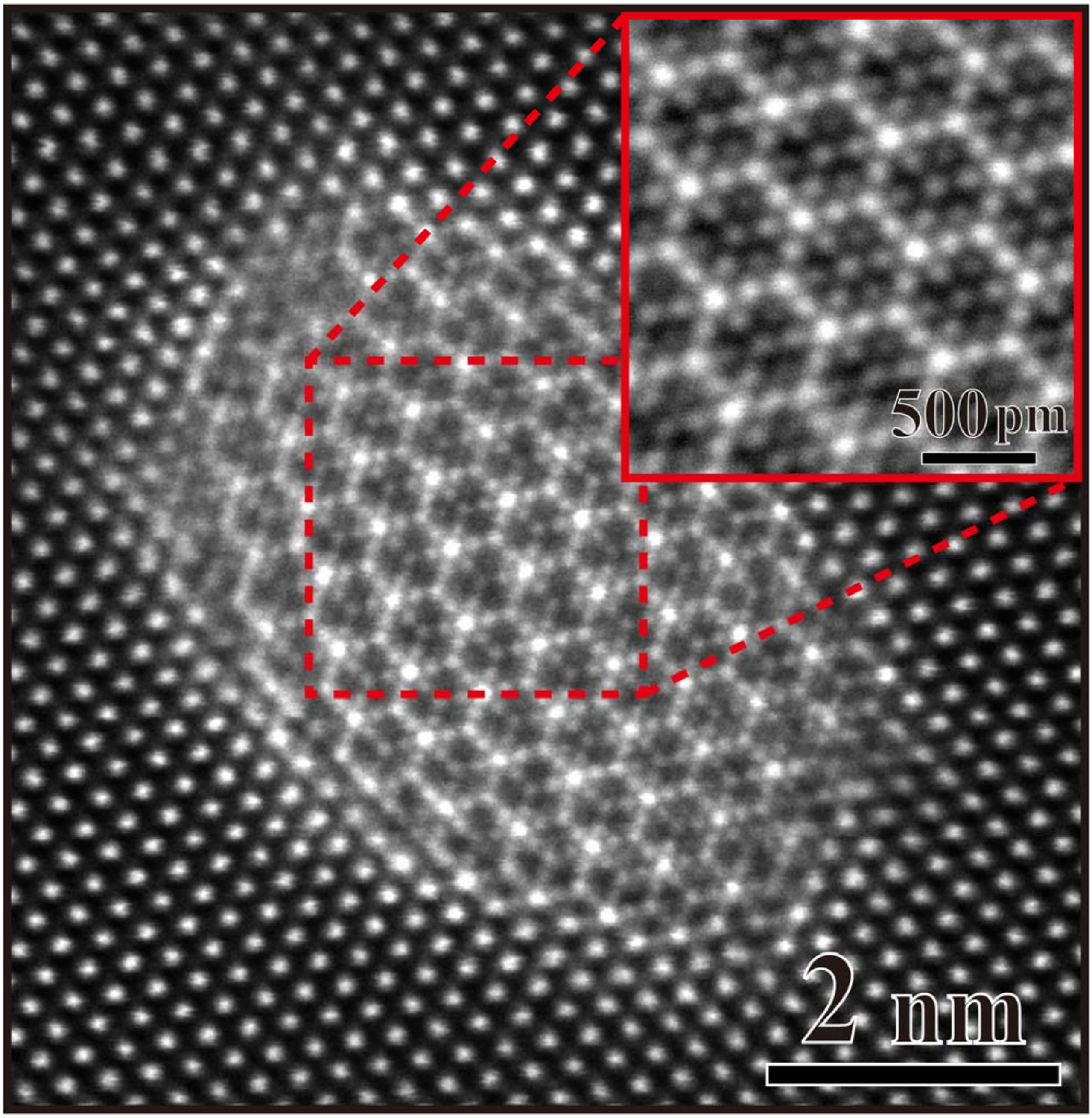
作品名稱：粒粒在鉬	
作品內容： The marvelous Mo_5O_{14} crystalline consists of MoO_6 octahedral and MoO_7 pentagonal bipyramids in tetragonal system. Ordered arrangement of Mo atoms in $(001)_{Mo5O14}$ plane was observed by HAADF image.	
作者姓名：丁一心 吳文偉	學校單位：國立交通大學材料所
E-Mail: vvv82128@gmail.com	



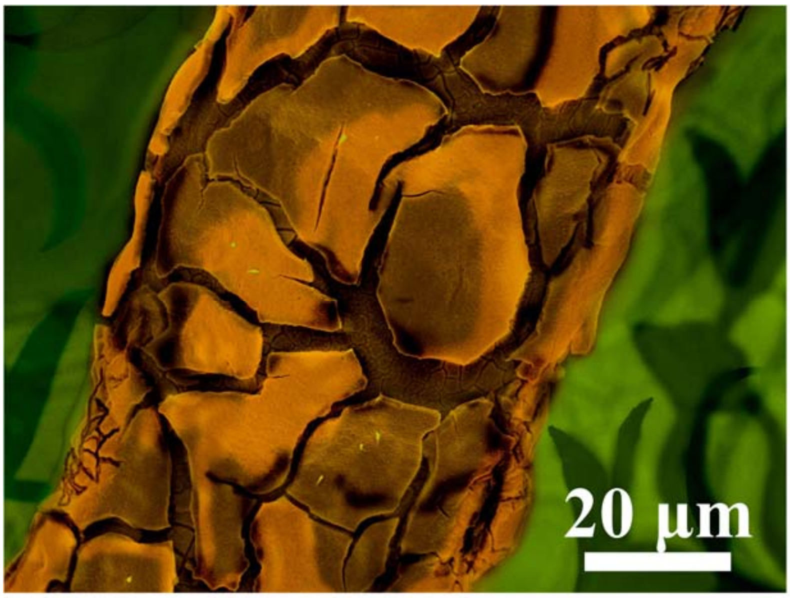
作品名稱: 半是糾結半是情	
作品內容: 半是糾結半是情的二系列鋁合金析出物交疊的形貌，如同人生中的半是蜜糖半是傷	
作者姓名: 蕭健男 鍾采甫 李威志 楊哲人	**學校單位** 國立台灣大學材料所
E-Mail f03527003@ntu.edu.tw	

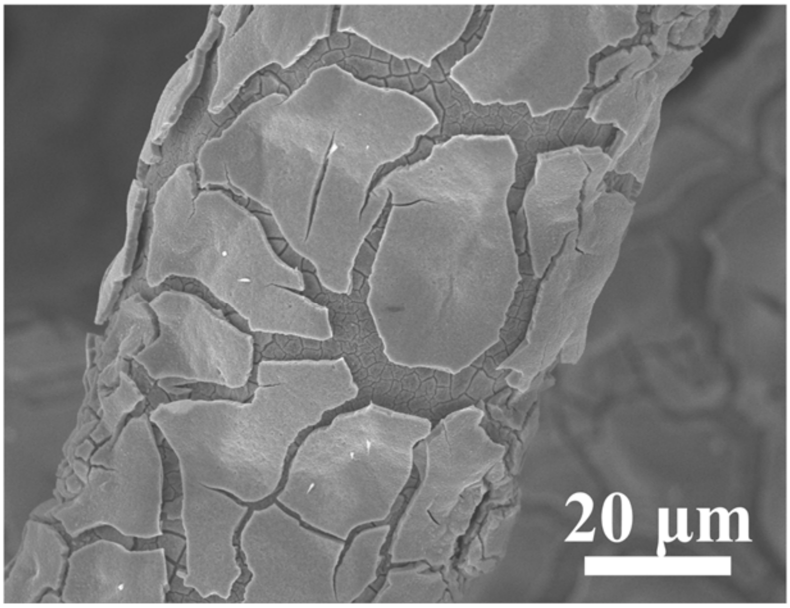


作品名稱: 奈米眼鏡蛇	
作品內容: 高端半導體製程，其外貌近似眼鏡蛇，邊界神秘面紗是否有應力造成所產生的 atomic lattice defects?	
作者姓名 鍾采甫 蕭健男 楊哲人	**學校單位** 國立台灣大學材料所
E-Mail f03527003@ntu.edu.tw	



作品名稱: 奈米小蜂窩	
作品內容: 原子級顯微，揭開 HCP 晶體結構之 η 析出物於七系列鋁合金下原子柱六軸對稱性排列近似蜂窩狀的神秘面紗。	
作者姓名 鍾采甫 李威志 蕭健男 楊哲人	**學校單位** 國立台灣大學材料所
E-Mail f03527003@ntu.edu.tw	





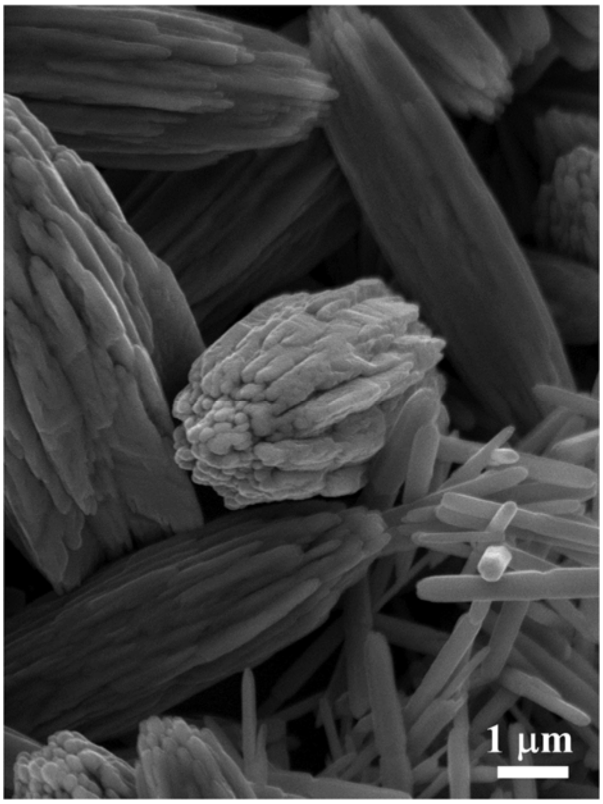
作品名稱　**樹枝生嫩芽，老木又逢春**

作品內容

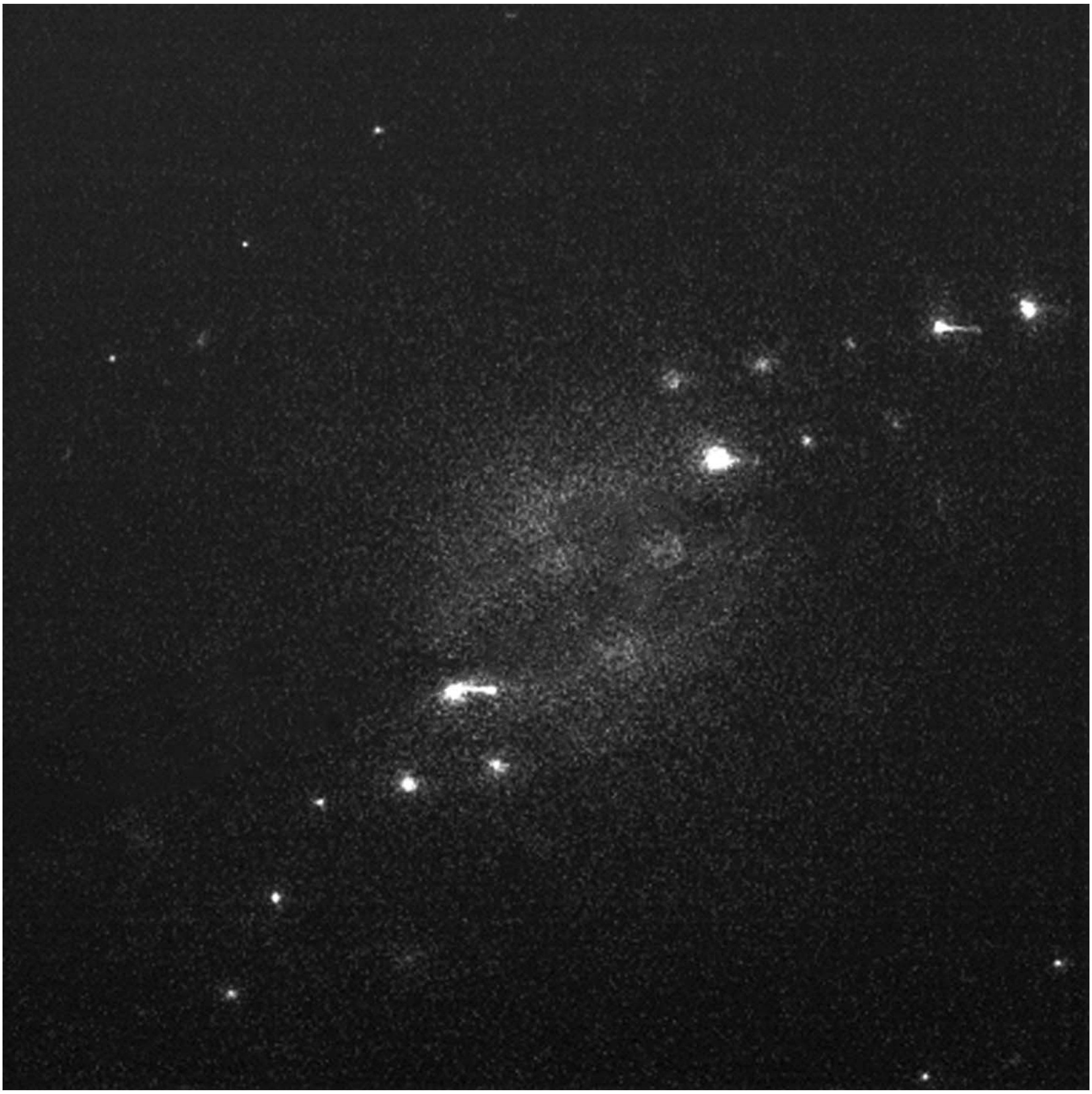
圖中掃描式電子顯微鏡影像為經電化學氧化過後硫化鎳奈米材料，因反應過程造成材料表面膨脹而造成龜裂，有如即將枯萎的樹枝倒臥在新生的綠嫩芽上，呈現自然界一代又一代生生不息。

作者姓名 **劉愷洋、陳智彥**　**學校單位** **中山大學材料與光電科學學系**

E-Mail boy67639525@gmail.com

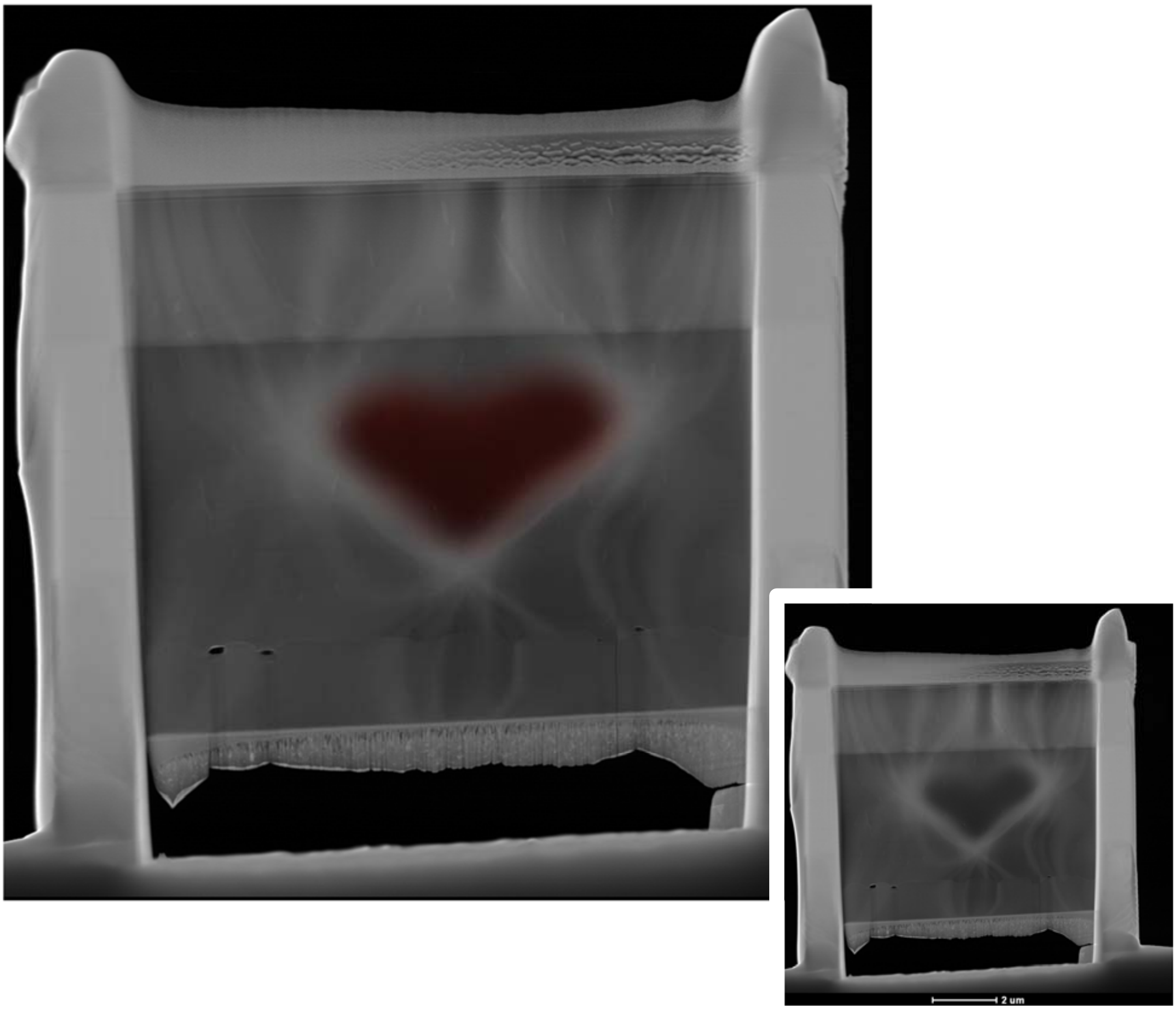


作品名稱：白玉苦瓜	
作品內容： 氧化鋅晶體柱成長前未於基板表面沉積晶種層，SEM 照片顯示氧化鋅與基板界面因缺乏成核點而生長出無序的氧化鋅。透過影像後製技術將散亂的氧化鋅繪製成苦瓜，呼應余光中於《白玉苦瓜》中所欲表達『瓜而曰苦，正象徵生命的現實』。	
作者姓名:曾嘉頡、李孟軒、陳智彥	學校單位:中山大學材料與光電科學學系
E-Mail : asd1120851120@gmail.com	

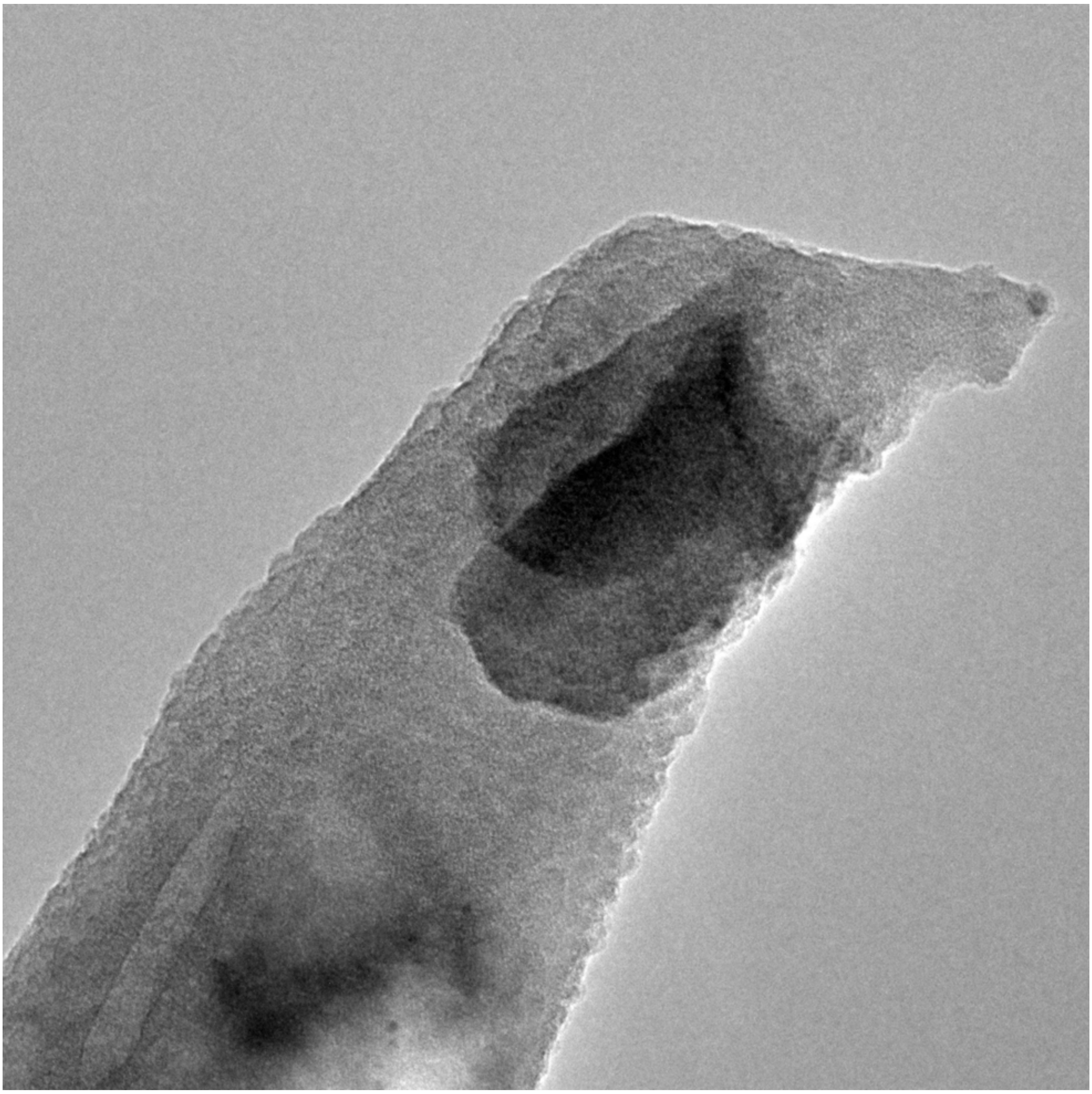


作品名稱　Galaxy	
作品內容 氧化鋁的晶體繞射，就像銀河一樣。	
作者姓名 彭裕庭	**學校單位** 國立清華大學
E-Mail trevorpeng9654@gmail.com	

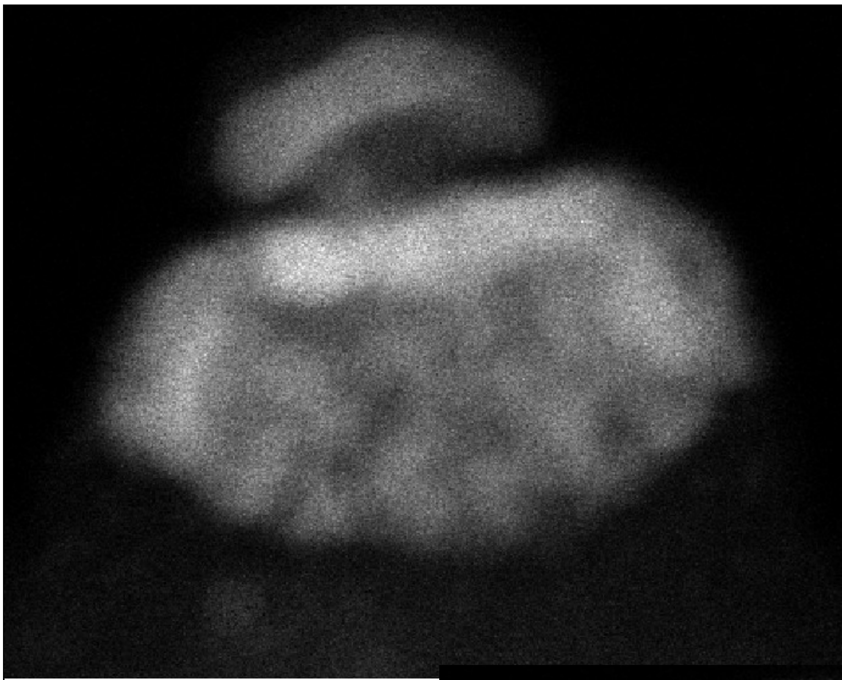
作品名稱　奮力一搏	
作品內容 只要抓住機遇，奈米線萌芽後就能快速生長。	
作者姓名 黃柏文 謝健	**學校單位 國立聯合大學材料科學工程學系**
E-Mail : bobo03267@gmail.com , jshieh@nuu.edu.tw	

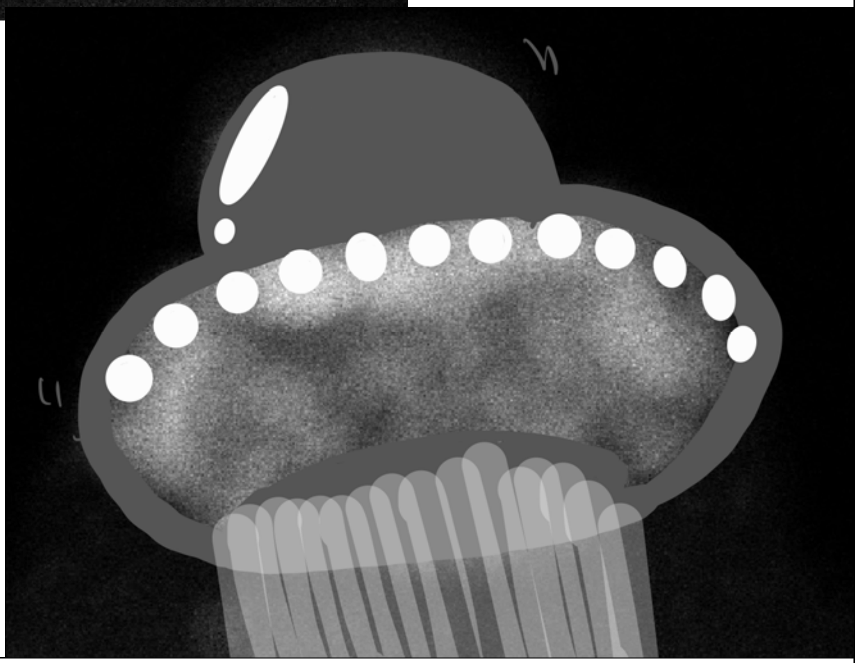


作品名稱：不完美之心 – 來自缺陷的你	
作品內容： 在不完美的缺陷下，意外產生的愛心，如同人生一般充滿驚奇。	
作者姓名：黃正堯、賴人豪、顏鴻威	學校單位：台灣大學材料所
E-Mail：F05527001@ntu.edu.tw	

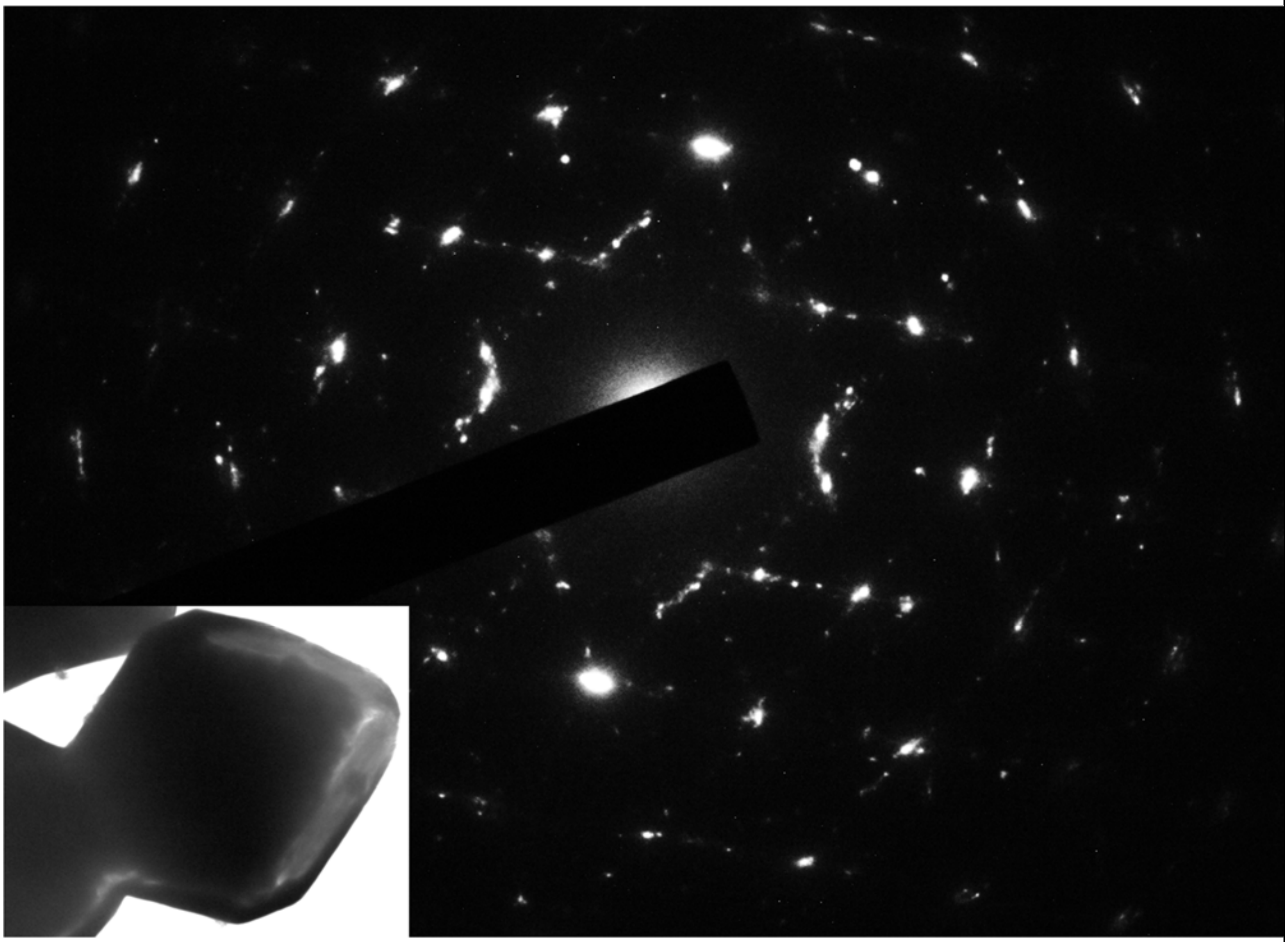


作品名稱　finFET 來福	
作品內容 半導體 finFET 之針狀樣品	
作者姓名 劉宇倫	**學校單位** 國立清華大學 工程與系統科學系
E-Mail kc25566@gmail.com	

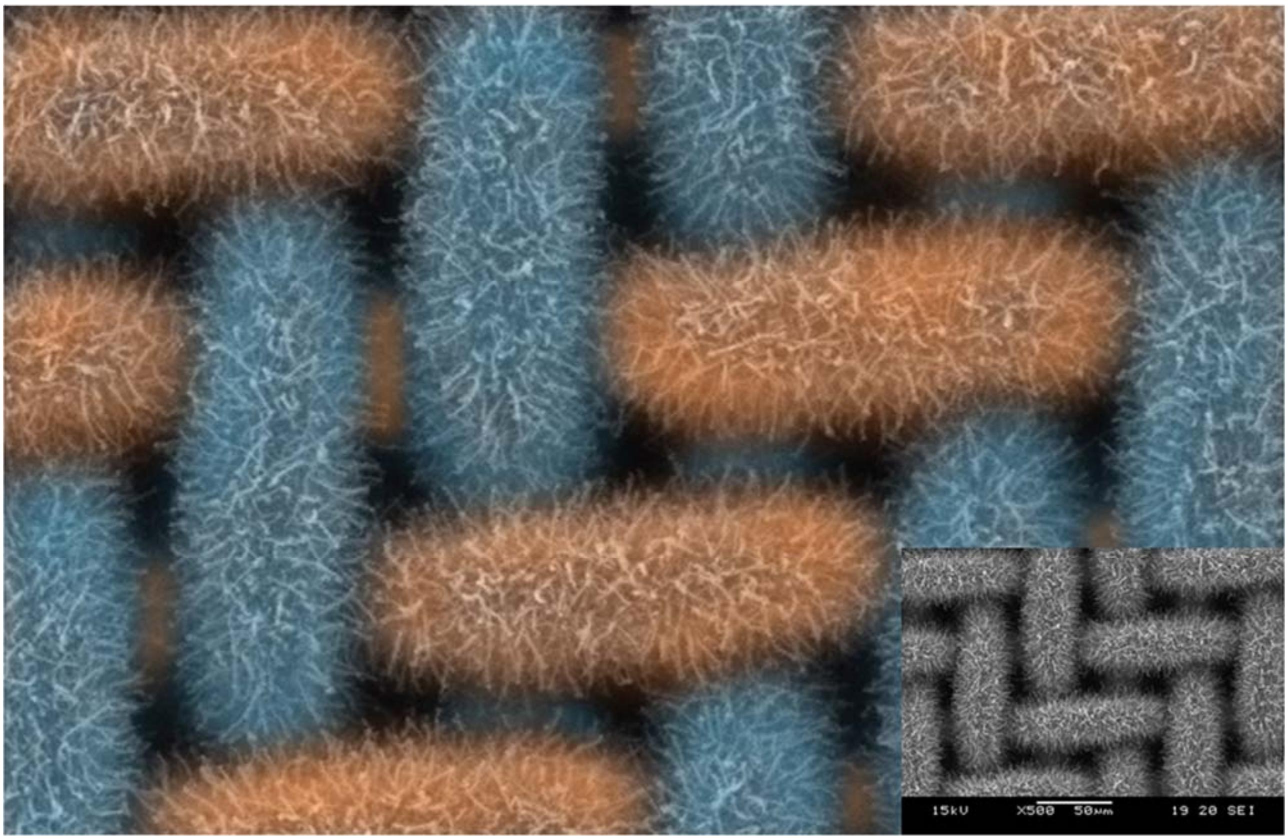




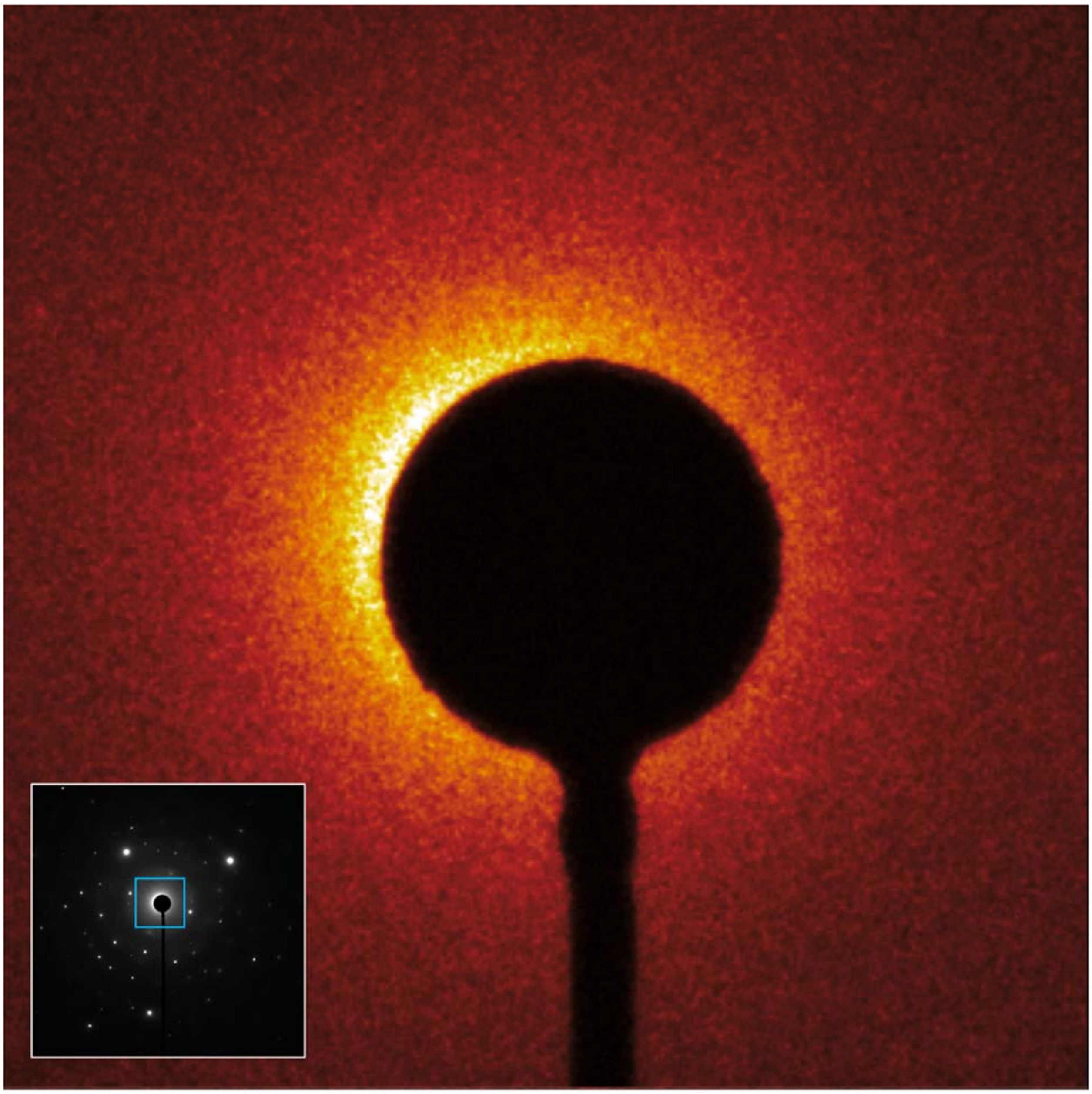
作品名稱 **Unidentified Flying Object**	
作品內容 無心插柳之下產生的針狀樣品之 FIB 的 Pt 鍍膜保護層，就像被偶然撞見的 UFO 劃過天際。	
作者姓名 陳穎	**學校單位** 國立清華大學工程與系統科學系
E-Mail in1013in@gmail.com	



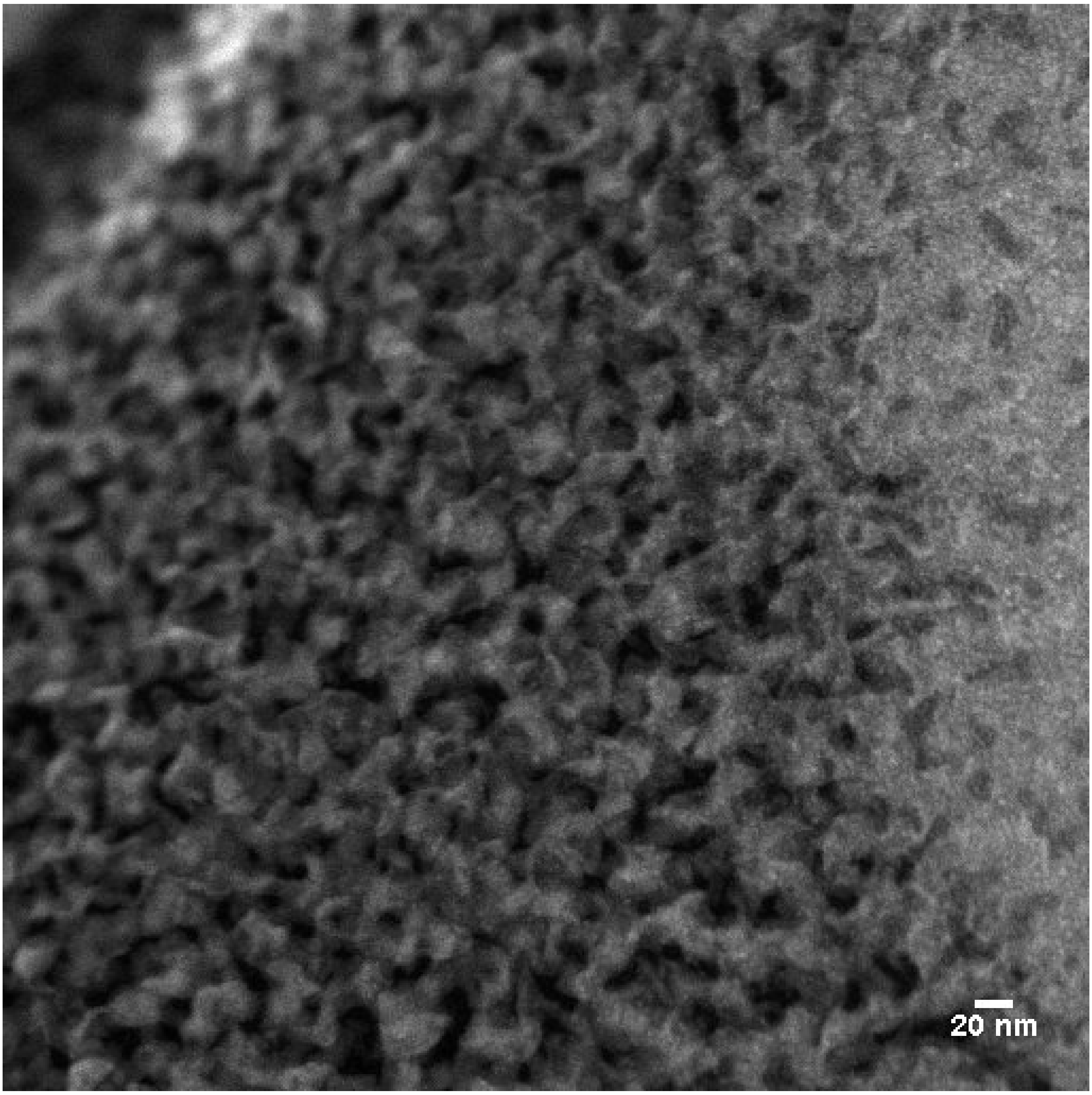
作品名稱　祈願之石	
作品內容 奈米氧化銀八面體與電子束交互作用，電子在氧化銀晶格與被電子束還原金屬銀晶格間繞射，破壞(氧化銀)與新生(銀)並存。	
作者姓名 呂煉明, 黃暄益, 呂明諺	**學校單位** 國立清華大學化學系、材料系
E-Mail coach101kfhc@gmail.com	



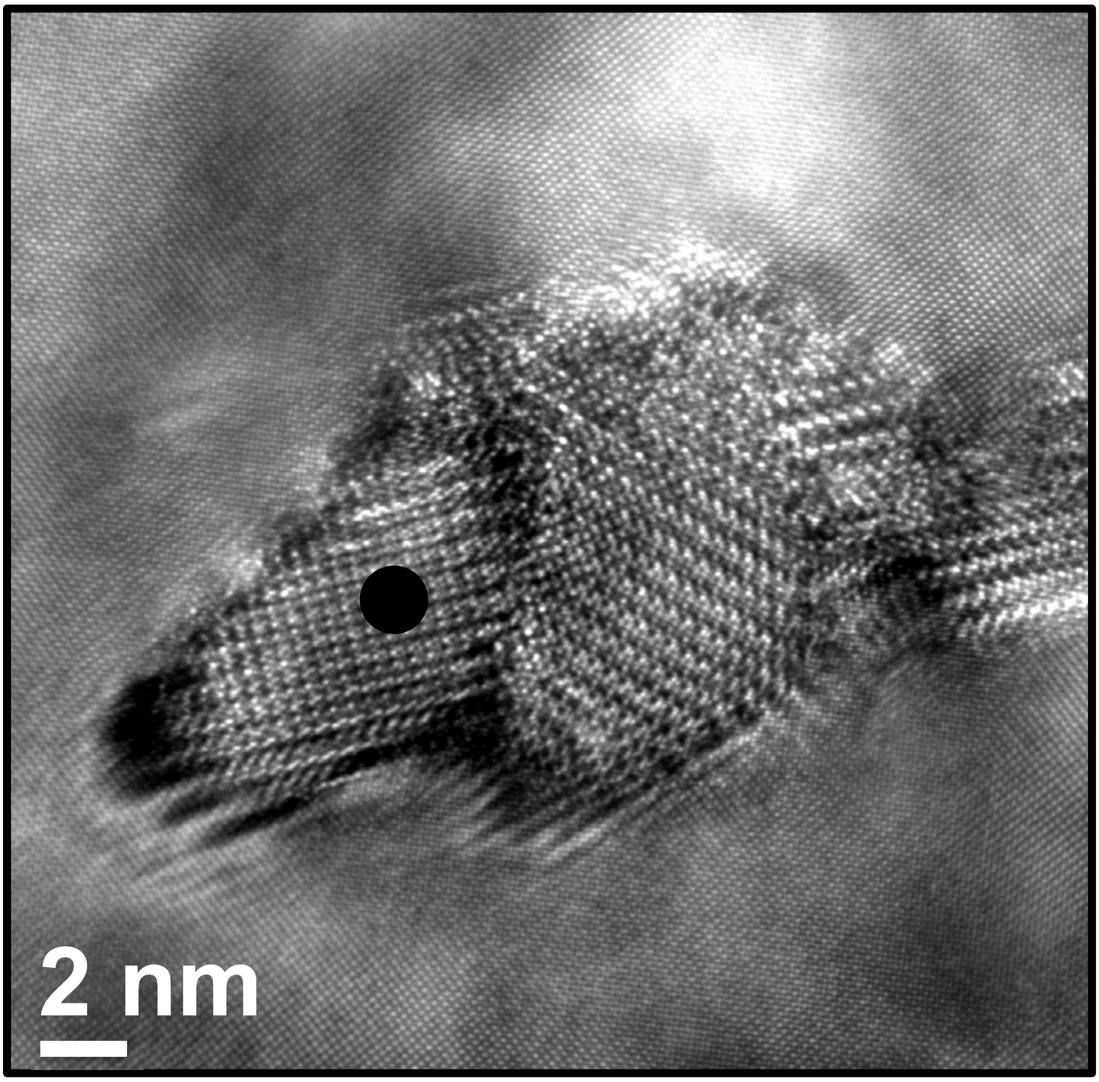
作品名稱: 同心協力	
作品內容: 金屬與玻璃的交織結合，讓材料煥然一新。	
作者姓名: 黃冠輔、謝健	**學校單位: 國立聯合大學材料系**
E-Mail: jshieh@nuu.edu.tw	



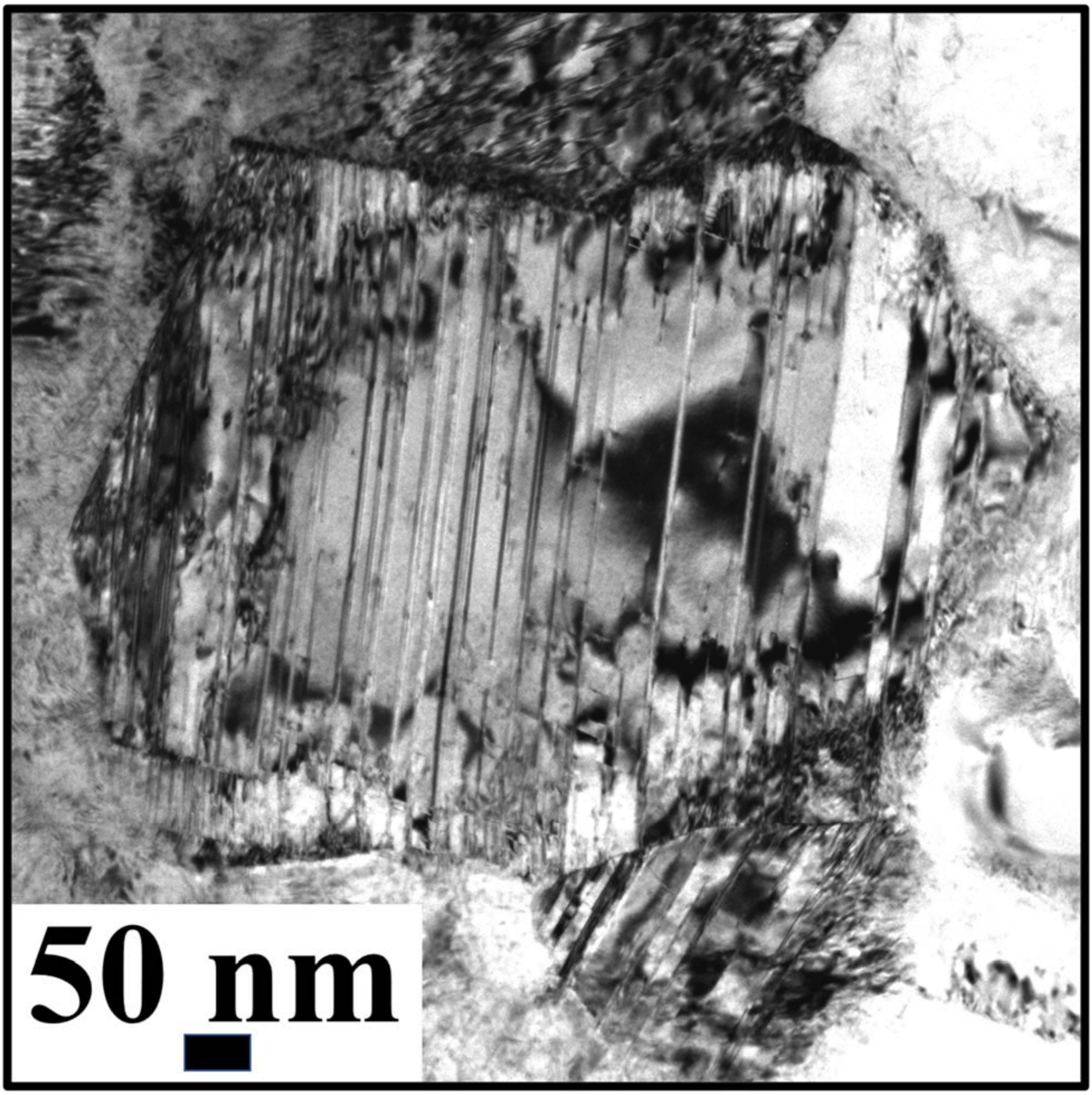
作品名稱 天狗食日	
作品內容 在日常繞射分析中，觀察罕見的天文現象	
作者姓名 蔡任豐	**學校單位** 工業技術研究院 材料與化工研究所
E-Mail renfong@itri.org.tw	



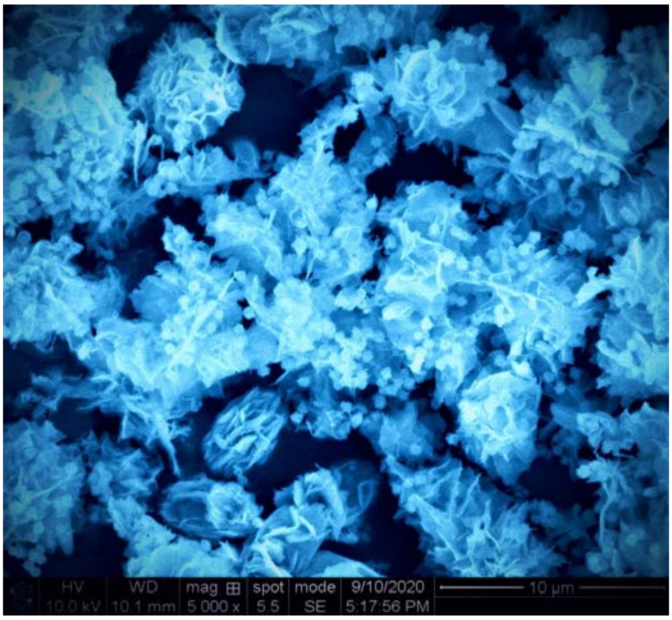
作品名稱 :亂石穿空，驚濤拍岸	
作品內容 雙螺旋 PS-P2VP 高分子聚合物在試片邊緣捲曲。	
作者姓名: 周晶瑩	**學校單位: 清華大學工程與系統科學**
E-Mail: crystal21320@gmail.com	

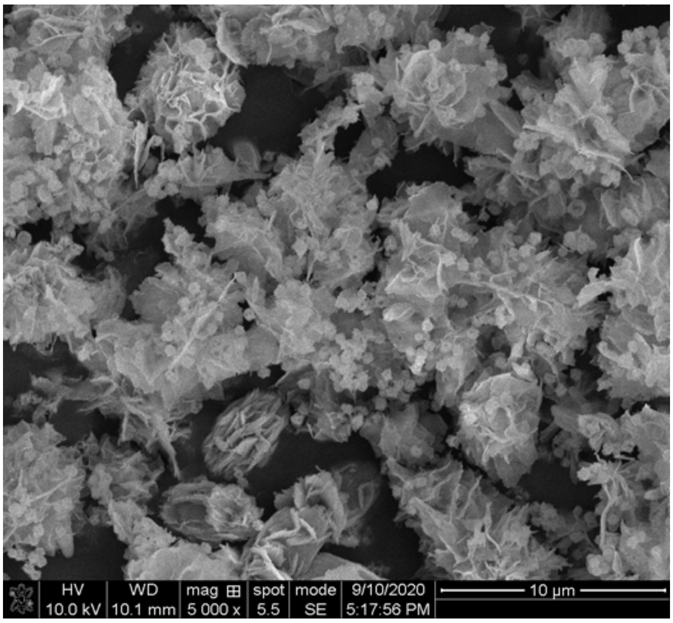


作品名稱: 奈米小老鼠	
作品內容: **AA2040** 鋁合金中 **S'** 析出奈米級別小老鼠，實鼠重大發現。	
作者姓名: 戴正凌, 楊哲人	學校單位: 台大材料所
E-Mail: peter29622@gmail.com	



作品名稱　世界最小的監獄	
作品內容 奈米大小等級的機械雙晶作為柵欄困住差排滑移。	
作者姓名 邱柏翰	學校單位 台灣大學
E-Mail d07527003@ntu.edu.tw	





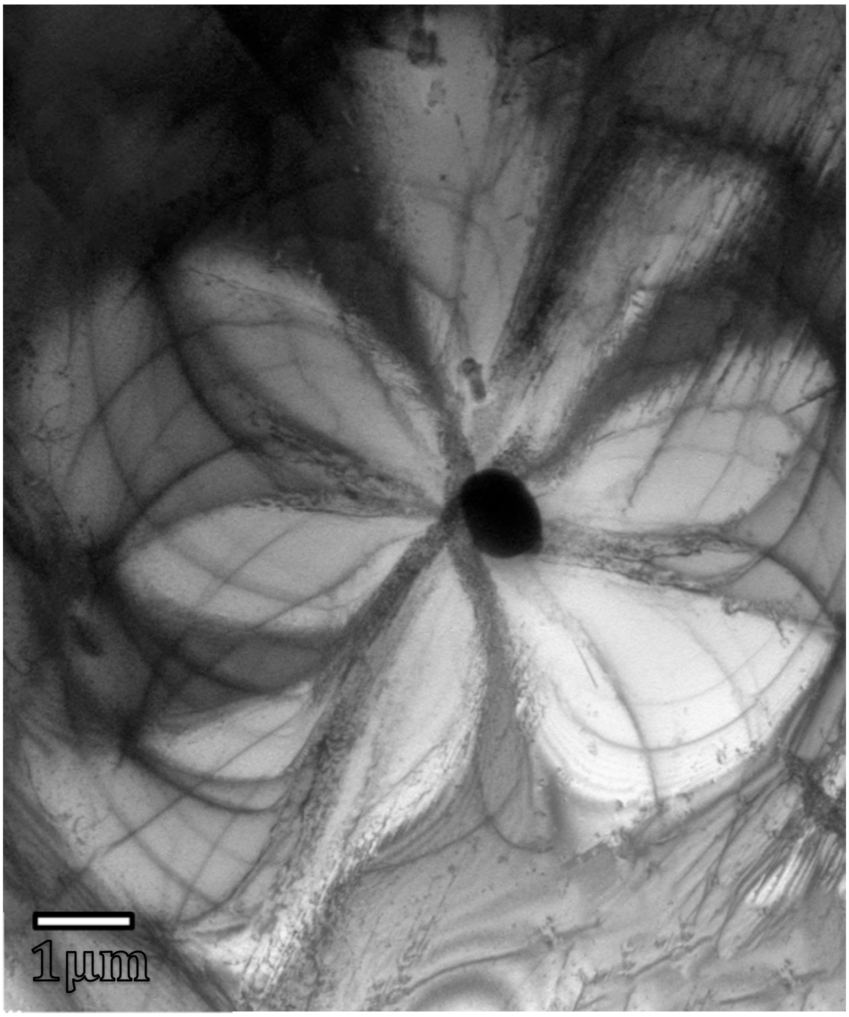
作品名稱　冰晶之花

作品內容

二氧化鈰摻雜釤形成的花狀次結構，在藍色繪圖下猶如冰晶中的花朵。

作者姓名:簡豪正 | **學校單位:台灣科技大學材料所**

E-Mail: trident8651@gmail.com



作品名稱　花惹發

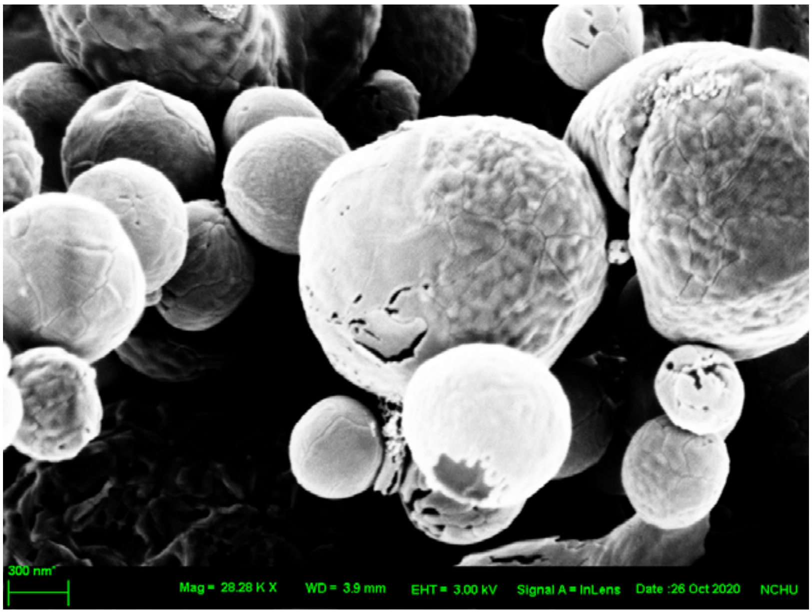
作品內容

顯微鏡下開出了一朵花 惹得人少女心噴發

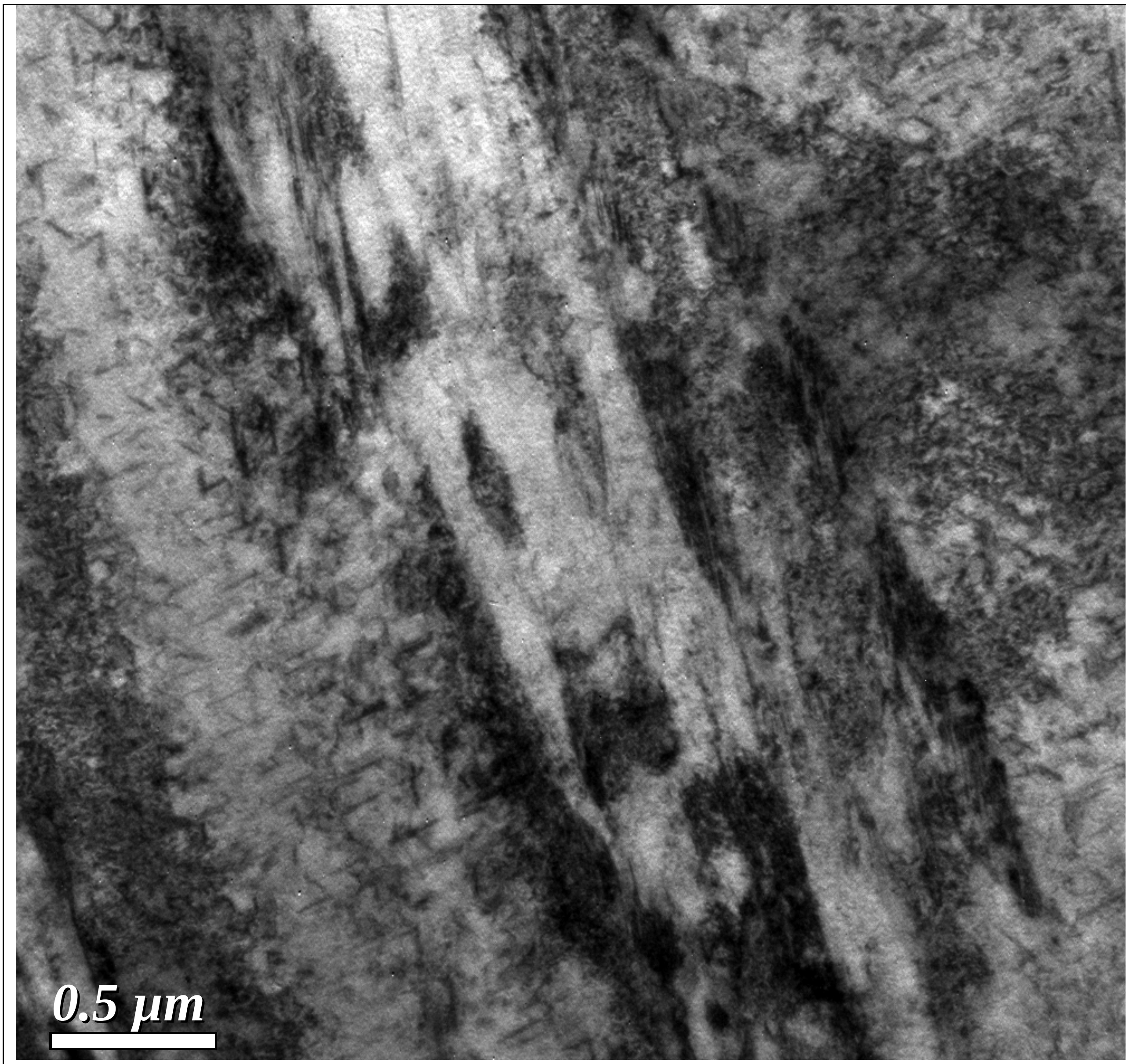
作者姓名 陳家俊

學校單位 台大材料所

E-Mail f08527053@ntu.edu.tw



作品名稱	Trick or Treat!!
作品內容 所製備之氧化鐵中空球，肚子裡需要糖果，不給糖就搗蛋。(下方為 SEM 原圖)	
作者姓名 徐培凱、林伯翰、吳柏佑	學校單位 國立臺灣科技大學材料科學與工程系
E-Mail D10804002@mail.ntust.edu.tw	



作品名稱:驚恐的臉龐	
作品內容 長條狀的 lath martensite，印著扭曲的臉龐，和知名畫作《吶喊》有幾分神似。	
作者姓名:程銘奕	**學校單位:**台灣大學材料系
E-Mail: mingyi1218@gmail.com	