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本期推荐报道 2022 年 2 月 Nature、Science 期刊上材料科学领域的部分最新论文。

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材料科学 2 月 Nature 论文

[1]**Evidence for a single-layer van der Waals multiferroic**

单层材料中的多铁状态证明

出版信息：Nature, 24 February 2022, Volume 602, Issue 7898

作者：Qian Song, Connor A. Occhialini, Emre Ergeçen, Batyr Ilyas et al.

第一作者单位：Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, USA.

全文链接：https://www.nature.com/articles/s41586-021-04337-x

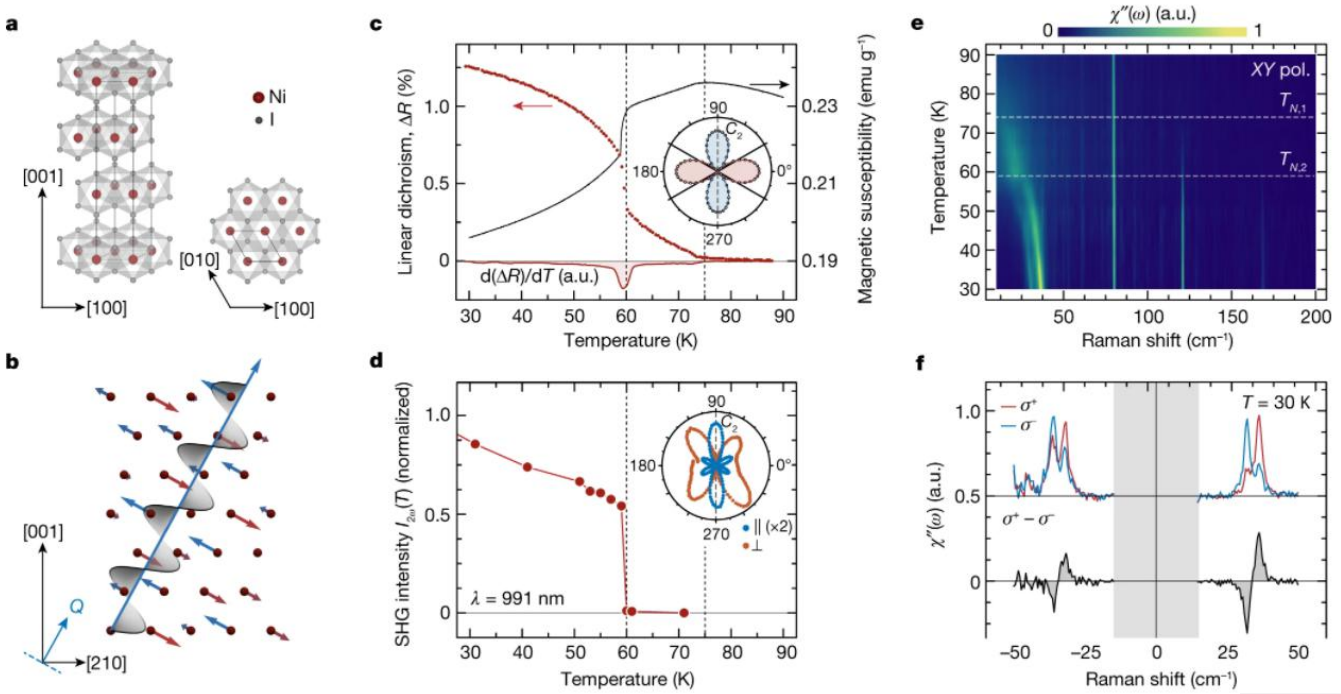
Abstract：Here we report the discovery of type-II multiferroic order in a single atomic layer of the transition-metal-based van der Waals material NiI2. The multiferroic state of NiI2 is characterized by a proper-screw spin helix with given handedness, which couples to the charge degrees of freedom to produce a chirality-controlled electrical polarization. We use circular dichroic Raman measurements to directly probe the magneto-chiral ground state and its electromagnon modes originating from dynamic magnetoelectric coupling. Combining birefringence and second-harmonic-generation measurements with theoretical modelling and simulations, we detect a highly anisotropic electronic state that simultaneously breaks three-fold rotational and inversion symmetry, and supports polar order. The evolution of the optical signatures as a function of temperature and layer number surprisingly reveals an ordered magnetic polar state that persists down to the ultrathin limit of monolayer NiI2.

摘要翻译：在此，我们报告在过渡金属材料 NiI2 的单个原子层中发现了 ii 型多铁有序结构。NiI2 多铁态的特征是具有给定手性的自旋螺旋，它与电荷自由度耦合产生手性控制的电极化。

我们利用圆二色拉曼测量直接探测由动态磁电耦合产生的磁手性基态及其电磁模。将双折射和二次谐波测量与理论建模和模拟相结合，我们发现了一个高度各向异性的电子态，它同时打破了三次旋转和反演对称，并支持极序。

随着温度和层数的变化，光信号的演化出人意料地揭示了 NiI2 单分子层的有序磁极态一直持续到超薄极限。

文中插图：



[2]**Free-standing homochiral 2D monolayers by exfoliation of molecular crystals**

自支撑手性二维单层分子晶体

出版信息：Nature, 24 February 2022, Volume 602, Issue 7898

作者：Jinqiao Dong, Lingmei Liu, Chunxia Tan, Qisong Xu, Jiachen Zhang et al

第一作者单位：School of Chemistry and Chemical Engineering, Frontiers Science Center for Transformative Molecules and State Key Laboratory of Metal Matrix Composites, Shanghai Jiao Tong University,Shanghai, P. R. China.

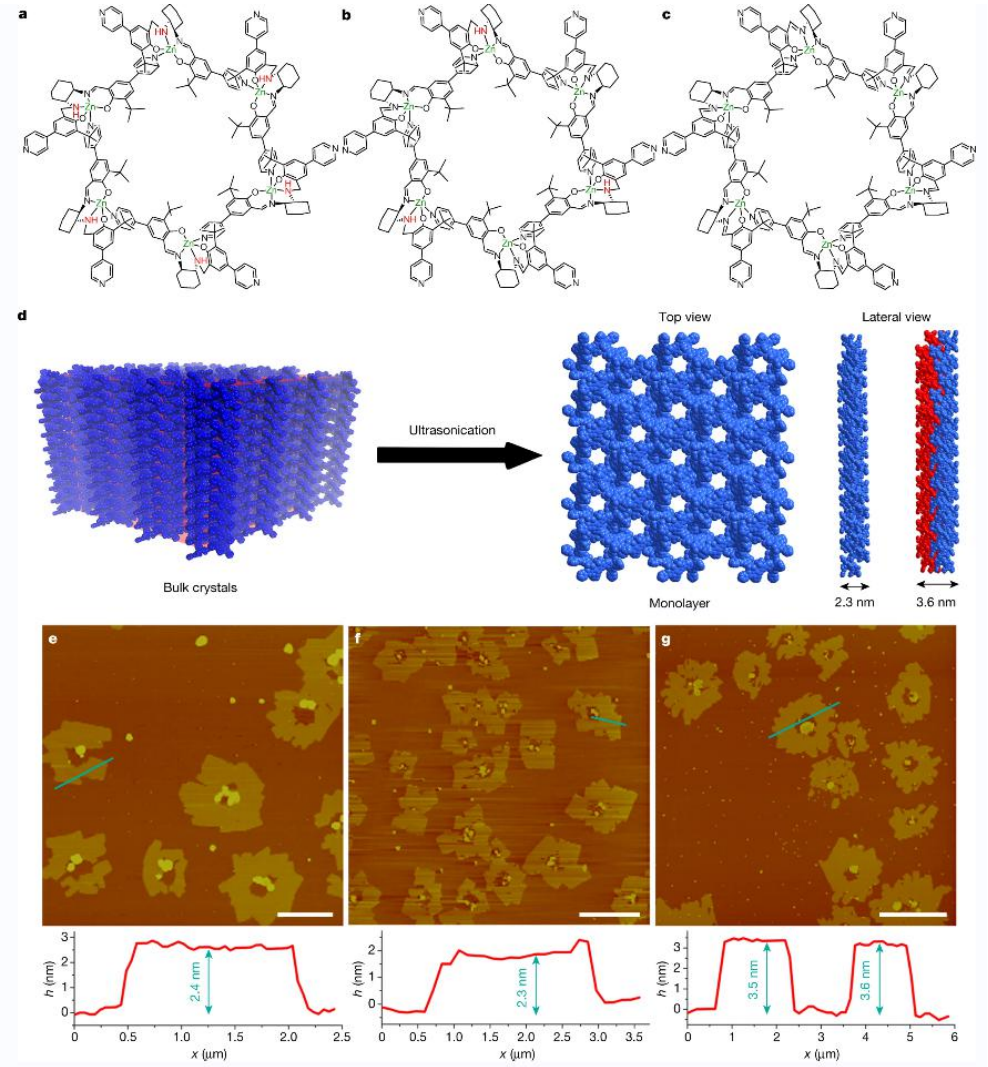
国内相关报道：https://news.sjtu.edu.cn/jdzh/20220224/167641.html

全文链接：https://www.nature.com/articles/s41586-022-04407-8

Abstract：We show here that crystals composed of discrete supramolecular coordination complexes can be exfoliated by sonication to give free-standing monolayers approximately 2.3 nanometres thick with aspect ratios up to approximately 2,500:1, sustained purely by apolar intermolecular interactions. These nanosheets are characterized by atomic force microscopy and high-resolution transmission electron microscopy, confirming their crystallinity. The monolayers possess complex chiral surfaces derived partly from individual supramolecular coordination complex components but also from interactions with neighbours. In this respect, they represent a distinct type of material in which molecular components are all equally exposed to their environment, as if in solution, yet with properties arising from cooperation between molecules, because of crystallinity.

摘要翻译：我们在此表明，由离散的超分子配位配合物组成的晶体可以通过超声作用剥离，形成独立的单层膜，其厚度约为 2.3 纳米，纵横比约为 2500:1，并完全由极性分子间相互作用维持。这些纳米片通过原子力显微镜和高分辨率透射电子显微镜进行了表征，证实了它们的结晶度。单分材料具有复杂的手性表面，部分来源于单个超分子配位复合物，也来源于与相邻分子的相互作用。在这方面，它们代表了一种独特的材料类型。在这种材料中，所有分子成分都相同地暴露在其环境中，就像在溶液中一样，但分子之间的合作因结晶性而产生了特性。

文中插图：



[3]**A highly distorted ultraelastic chemically complex Elinvar alloy**

一种高度变形超弹性化学复杂的艾林瓦合金

出版信息：Nature, 10 February 2022, VOL 602, ISSUE 7896

作者：Q. F. He, J. G. Wang, H. A. Chen, Z. Y. Ding, Z. Q. Zhou, L. H. Xiong, et al.

第一作者单位：Department of Mechanical Engineering, City University of Hong Kong, Kowloon, Hong Kong, China

全文链接：https://www.nature.com/articles/s41586-021-04309-1

Abstract： The development of high-performance ultraelastic metals with superb strength, a large elastic strain limit and temperature-insensitive elastic modulus (Elinvar effect) are important for various industrial applications, from actuators and medical devices to high-precision instruments. The elastic strain limit of bulk crystalline metals is usually less than 1 per cent, owing to dislocation easy gliding. Shape memory alloys—including gum metals and strain glass alloys—may attain an elastic strain limit up to several per cent, although this is the result of pseudo-elasticity and is accompanied by large energy dissipation. Recently, chemically complex alloys, such as ‘high-entropy’ alloys, have attracted tremendous research interest owing to their promising properties. In this work we report on a chemically complex alloy with a large atomic size misfit usually unaffordable in conventional alloys. The alloy exhibits a high elastic strain limit (approximately 2 per cent) and a very low internal friction (less than 2 × 10−4) at room temperature. More interestingly, this alloy exhibits an extraordinary Elinvar effect, maintaining near-constant elastic modulus between room temperature and 627 degrees Celsius (900 kelvin), which is, to our knowledge, unmatched by the existing alloys hitherto reported.

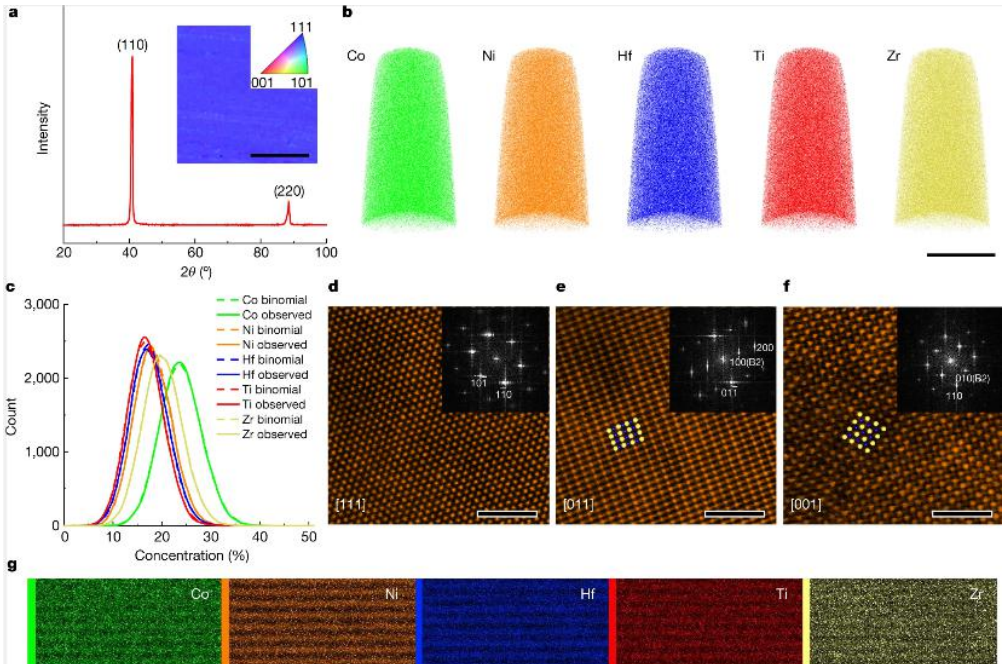
摘要翻译：高性能超弹性金属的研发具有超高强度、大弹性应变极限和温度不敏感的弹性模量（艾林瓦效应），对于从致动器、医疗设备到高精度仪器的各种工业应用都至关重要。由于位错易滑动，体晶金属的弹性应变极限通常小于 1%。

形状记忆合金（包括胶质金属和应变玻璃合金）的弹性应变极限可高达几个百分点，虽然这是伪弹性的结果，且伴随着巨大的能量耗散。近年来，化学性质复杂的合金，如“高熵”合金，因其良好性能引发了人们广泛的研究兴趣。

在这项工作中，研究组报道了一种化学复杂的合金，其原子尺寸错配较大，常规合金通常无法承受。该合金在室温下具有较高的弹性应变极限（约 2%）和极低的内耗（小于 2 × 10−4）。

更有趣的是，这种合金表现出非凡的艾林瓦效应，在室温和 627℃（900K）之间的弹性模量近乎恒定，迄今为止报道的现有合金均无法与之比拟。

文中插图：



[4]**Irreversible synthesis of an ultrastrong two-dimensional polymeric material**

超强二维聚合物材料的不可逆合成

出版信息: Nature, 3 February 2022, Volume 602 Issue 7895

作者：Yuwen Zeng, Pavlo Gordiichuk, Takeo Ichihara, Ge Zhang et al.

第一作者单位：Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA

全文链接：https://www.nature.com/articles/s41586-021-04296-3

Abstract：

Polymers that extend covalently in two dimensions have attracted recent attention as a means of combining the mechanical strength and in-plane energy conduction of conventional two-dimensional (2D) materials with the low densities, synthetic processability and organic composition of their one-dimensional counterparts. Here we demonstrate a homogenous 2D irreversible polycondensation that results in a covalently bonded 2D polymeric material that is chemically stable and highly processable. Further processing yields highly oriented, free-standing films that have a 2D elastic modulus and yield strength of 12.7 ± 3.8 gigapascals and 488 ± 57 megapascals, respectively. This synthetic route provides opportunities for 2D materials in applications ranging from composite structures to barrier coating materials.

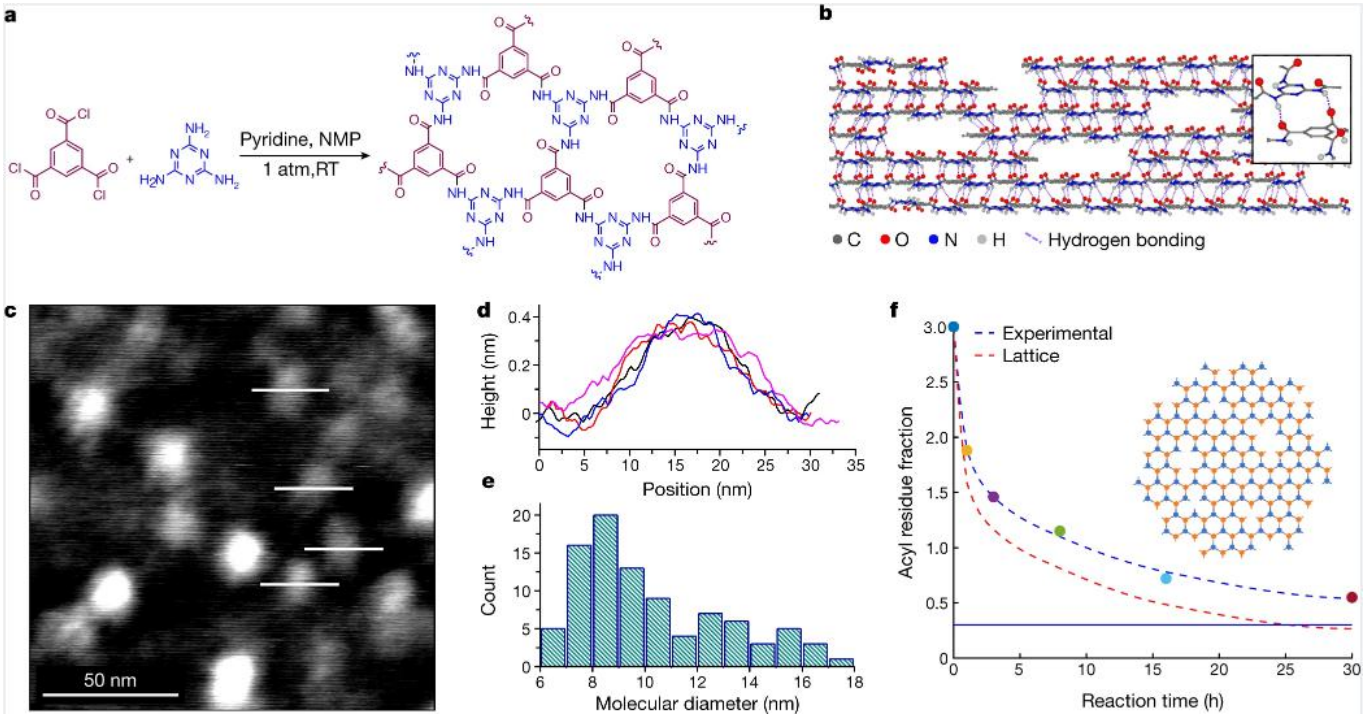
摘要翻译：

二维共价延伸的聚合物作为一种将传统二维材料的机械强度和面内能量传导与一维材料的低密度、合成加工性能和有机组成相结合的手段，在近期引起了人们的关注。

在此，我们展示了一种二维不可逆聚合，它可以生成一种化学稳定且易加工的二维聚合材料。

进一步加工可得到高度定向的独立薄膜，其二维弹性模量和屈服强度分别为 12.7±3.8 GPa 和 488±57 GPa。这一合成路线为二维材料的应用提供了机会，从复合结构到屏障涂层材料。

文中插图：



材料科学　2 月 Science 论文

[1]**A damage-tolerant, dual-scale, single-crystalline microlattice in the knobby starfish, Protoreaster nodosus**

馒头海星骨骼中的抗损伤、双尺度、单晶微晶格结构

出版信息：Science, 11 FEB 2022, VOL 375, ISSUE 6581

作者：TING YANG, HONGSHUN CHENZIAN JIA, ZHIFEI DENG et al.

第一作者单位：Department of Mechanical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA

全文链接：https://www.science.org/doi/10.1126/science.abj9472

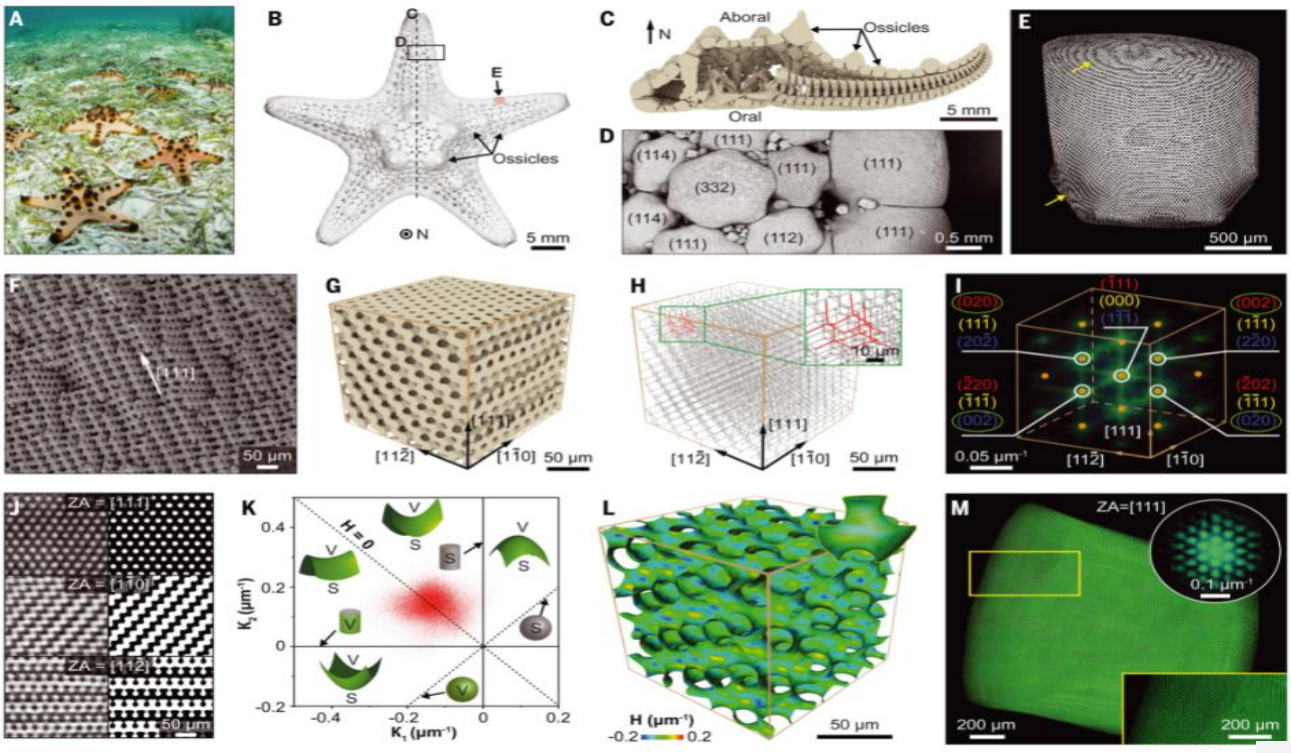
Abstract：Cellular solids (e.g., foams and honeycombs) are widely found in natural and engineering systems because of their high mechanical efficiency and tailorable properties. While these materials are often based on polycrystalline or amorphous constituents, here we report an unusual dual-scale, single-crystalline microlattice found in the biomineralized skeleton of the knobby starfish, Protoreaster nodosus. This structure has a diamond-triply periodic minimal surface geometry (lattice constant, approximately 30 micrometers), the [111] direction of which is aligned with the c-axis of the constituent calcite at the atomic scale. This dual-scale crystallographically coaligned microlattice, which exhibits lattice-level structural gradients and dislocations, combined with the atomic-level conchoidal fracture behavior of biogenic calcite, substantially enhances the damage tolerance of this hierarchical biological microlattice, thus providing important insights for designing synthetic architected cellular solids.

摘要翻译：多孔固体（如泡沫和蜂窝）由于其高机械效率和可定制的特性，在自然和工程系统中被广泛发现。虽然这些材料通常是基于多晶或无定形成分，但在此，我们报告在馒头海星的骨骼中发现的一种不寻常的双尺度、单晶微晶格结构。

这种结构具有金刚石三周期的最小表面几何形状（晶格常数约 30 微米），其方向在原子尺度上与组成方解石的 c 轴对齐。

这种双尺度晶体协同微点阵表现出晶格级的结构梯度和位错，结合生物成因方解石原子级的贝壳状断裂，大大提高了这种分层生物微点阵的损伤容忍度，对设计合成多孔结构固体材料有借鉴意义。

文中插图：



[2]**Self-assembled monolayers direct a LiF-rich interphase toward long-life lithium metal batteries**

自组装单分子层形成富 LiF 界面相，实现长寿命锂金属电池

出版信息：Science, 18 FEBRUARY 2022, VOL 375, ISSUE 6582

作者：YUJING LIU, XINYONG TAO, YAO WANG, CHI JIANG, CONG MA, OUWEI SHENG, ET AL.

第一作者单位：College of Materials Science and Engineering, Zhejiang University of Technology, Hangzhou 310014, People’s Republic of China.

国内相关报道：http://news.cyol.com/gb/articles/2022-02/21/content_v72J8Sljq.html

全文链接：https://www.science.org/doi/10.1126/science.abn1818

Abstract： High‐energy density lithium (Li) metal batteries (LMBs) are promising for energy storage applications but suffer from uncontrollable electrolyte degradation and the consequently formed unstable solid-electrolyte interphase (SEI). In this study, we designed self-assembled monolayers (SAMs) with high-density and long-range‐ordered polar carboxyl groups linked to an aluminum oxide‐coated separator to provide strong dipole moments, thus offering excess electrons to accelerate the degradation dynamics of carbon-fluorine bond cleavage in Li bis(trifluoromethanesulfonyl)imide. Hence, an SEI with enriched lithium fluoride (LiF) nanocrystals is generated, facilitating rapid Li+ transfer and suppressing dendritic Li growth. In particular, the SAMs endow the full cells with substantially enhanced cyclability under high cathode loading, limited Li excess, and lean electrolyte conditions. As such, our work extends the long-established SAMs technology into a platform to control electrolyte degradation and SEI formation toward LMBs with ultralong life spans.

摘要翻译：高能量密度锂（Li）金属电池（LMB）有望应用于储能，但由于其电解质不可控降解，会形成不稳定的固电解质界面（SEI）。

在这项研究中，研究组设计了具有高密度和长程有序极性羧基的自组装单分子膜（SAM），与氧化铝涂层隔膜相连以提供强大偶极矩，从而提供多余的电子以加速锂双（三氟甲磺酰）亚胺中碳-氟键断裂的降解动力学。由此可生成富氟化锂（LiF）纳米晶的 SEI，促进 Li+的快速转移，并抑制 Li 枝晶的生长。尤其是在高阴极负载、有限锂过剩和低电解质条件下，SAM 赋予了全电池显著增强的循环能力。

因此，该工作将长期建立的 SAM 技术扩展到一个平台，以控制电解质降解和 SEI 的形成，从而实现超长寿命的 LMB。

文中插图：