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Synthesis of High-Entropy Alloy Arrays with Liquid Metal Nanoreactor

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Metal arrays with well-defined spatial arrangement exhibit coupling properties owing to periodic geometries[1]. The high-entropy design provides a high degree of freedom in the chemical composition to design the metal-external interactions. It endows the array structures with high chemical stability and excellent mechanical properties[2]. Therefore, it is important to realize the controllable construction of high-entropy alloy (HEA) array structures, which will facilitate the development of catalysis[3], electronics[4], and plasmonics[5].

The Fu group has been focusing on the controllable preparation of high-entropy materials. In previous work, we utilized the relatively negative mixing enthalpy of the liquid metal gallium (Ga) to achieve the universal synthesis of HEA and high-entropy oxides under mild conditions[6,7]. Given this, using the coalescence property of liquid metal to provide a restricted reaction environment enables the control of nucleation and growth of multiple elements (Fig. 1(a)). Hence, the HEA array has been achieved[8] (*Advanced Materials*, 2024, 36, 2403865).

The authors conducted the HEA array formation mechanism. The synthesis of HEA particles was performed under the circumstance of the presence or absence of liquid metal nanoreactors (Fig. 1(b), (c)). In a high-temperature, reductive atmosphere, based on the coalescence property of liquid metals driven by reducing the surface energy, a dynamic reaction environment was constructed, so that the conversion of the precursor into an alloy occurs in a restricted region. In contrast, the precursors consisted of pure metal salts produced multiple nanoparticles in each predefined isolated region. To further elaborate on the role of liquid metals, the authors also performed theoretical calculations, indicating that Ga has the weakest bonding with the substrate and that the Ga-containing system possesses the highest diffusion rate. These are beneficial to the movement of particles for achieving fusion. To explore the potential optical applications of high-entropy alloy arrays, the authors demonstrated holography imaging in a broad spectrum.

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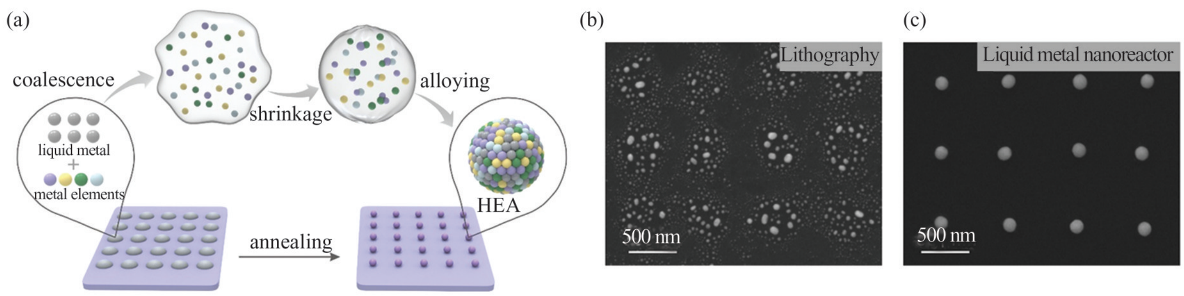

Fig. 1 Schematic illustration of the synthesis of HEA array (a), the comparison between the HEA array synthesis without liquid metal (b), and with liquid metal nanoreactor strategy (c)[8]

In summary, Prof. Fu's group and his collaborators have successfully achieved the general synthesis of the HEA array and demonstrated its application in holographic imaging. The strategy overcomes the contradiction between the modulation of high entropy and fine structure, providing ideas for constructing the array of other high entropy materials.

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液态金属纳米反应器辅助合成高熵合金阵列

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摘要: 得益于周期性几何结构, 具有明确空间排列的高熵合金(HEA)阵列有望促进纳米电子学、纳米光子学和催化领域的发展。然而, 由于多种元素的还原电势、成核势垒和聚集速率等理化性质差异使其容易随机成核和生长, 从而无法在预定位置形成单颗粒。本工作提出利用液态金属纳米反应器实现HEA阵列的构建。在合成过程中引入具有流变性的液态金属充当反应器, 基于液态金属为降低表面能而融合的特性构筑动态环境, 使得单个HEA粒子的成核生长发生在限定区域内。另一方面, 液态金属在基底上的低扩散能垒和合金体系的高扩散速率加速了聚合过程。因此, 制备出的HEA阵列具有均匀的周期性, 在宽光谱范围内表现出优异的全息响应。此策略为构筑其他高熵材料的阵列结构提供了新思路。

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