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ABSTRACT:

Fabricating Ultrathin Suspended Metal Membranes by Grain Boundary Interdiffusion in Supported Cu-Au Bilayers

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We investigated diffusion-controlled intermixing in thin Cu–Au bilayers (total thickness 30 nm) deposited on sapphire substrates. When Au served as the overlayer, annealing at elevated temperatures led to the formation of thin, single-crystalline, drum-like Au–Cu alloy membranes suspended over pores with lateral dimensions of up to 500 nm. The thinnest membranes were only 2-3 nm thick, representing a quasi-two-dimensional single-crystalline alloy.

Pore nucleation at the film–substrate interface was attributed to the grain-boundary Kirkendall effect, while their subsequent upward growth was explained in terms of strain-energy relaxation induced by Au–Cu interdiffusion. In contrast, reversing the stacking order of the deposited sublayers resulted in the formation of polycrystalline blisters.

We further demonstrated that the intermixing kinetics strongly depend on the stacking sequence: bilayers with Cu as the top layer exhibited significantly faster intermixing than those with the opposite stacking order. This asymmetry is discussed in terms of differences in the microstructure of the as-deposited films.

Overall, our work opens a new pathway for the fabrication of ultrathin, continuous metallic membranes.