Mechanical & Materials engineering
University of Nebraska-Lincoln
Nebraska Lincoln | NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

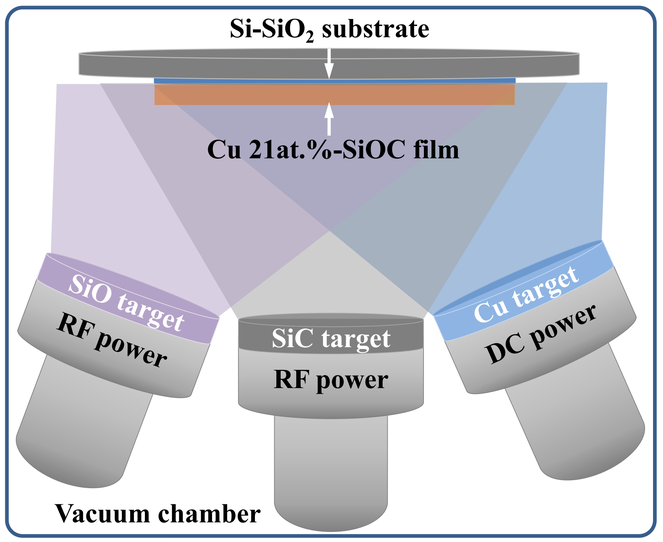
Ceramic nanowelding via in-situ growth of metal whiskers

Mingyu Gong, Kaisheng Ming, Qing Su, Chao Gu, Dongyue Xie, Michael Nastasi, Jian Wang

Ceramic nanowelding is extremely difficult to be achieved due to the high melting point, good insulation and low diffusivity of ceramic materials, and poor infiltration and large thermal expansion coefficients mismatch between ceramic and metal. Here, we demonstrated Metal-amorphous ceramic composites with high irradiation resistance can be used to glue ceramics and achieve high electric conductivity at extreme environments. Using Cu-SiOC composite film, we examined ceramic nanowelding through in-situ growth of Cu whiskers. The Cu whiskers can penetrate the whole film and joint the two films together, significantly increasing the conductivity of ceramic. This work was supported by NCESR and will be explored further for external funding.

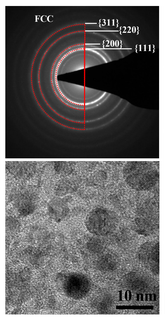
Cu-SiOC film fabrication

Co-sputtering Cu, SiO_2 and SiC targets by magnetron sputtering techniques at room temperature

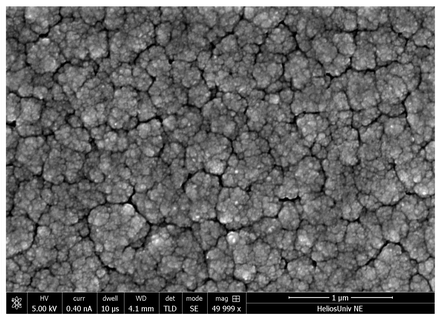


Microstructures in as-deposited state

TEM – cross-section view



SEM - plane view

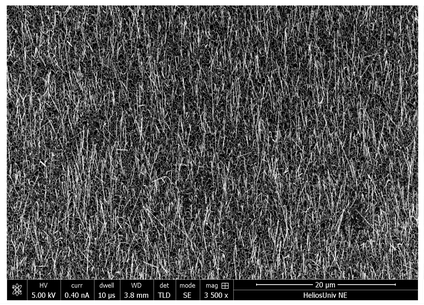


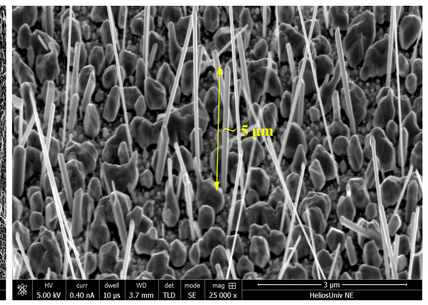
Columnar distribution of crystalline Cu nano-particles along the growth direction of the film

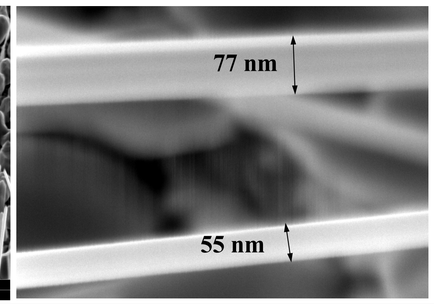
Formation of Cu whiskers by annealing (≧300 °C)

SEM - plane view

Cu whiskers: diameter < 100 nm; length ~ 5 μm

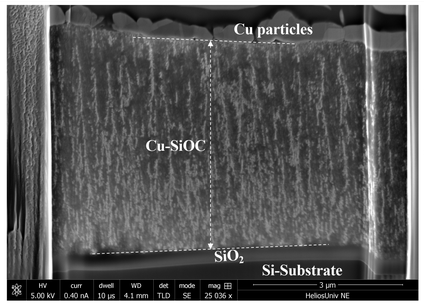


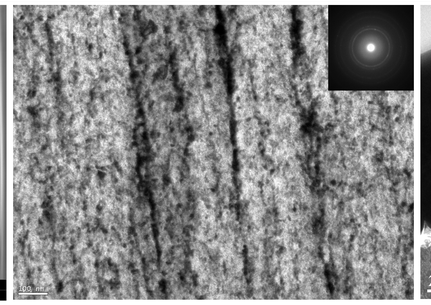


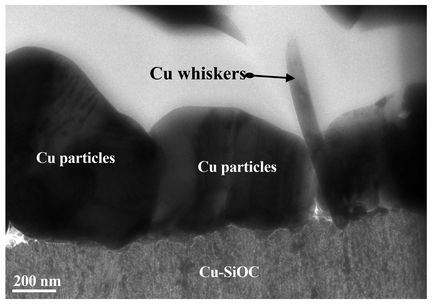


TEM/SEM cross-section view

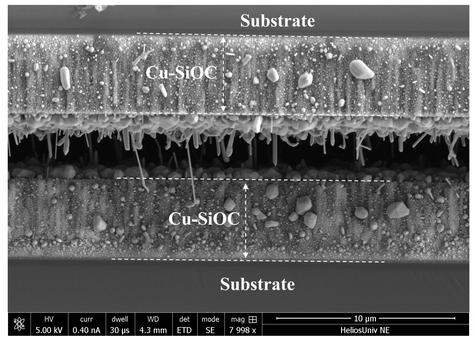
Cu whiskers penetrate the whole film

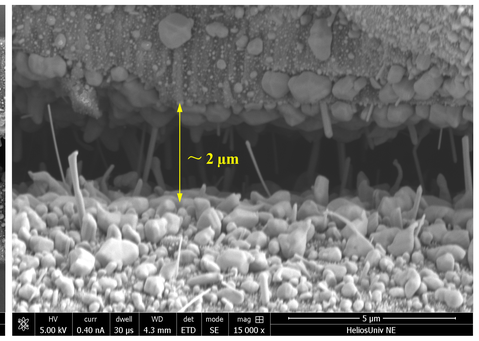


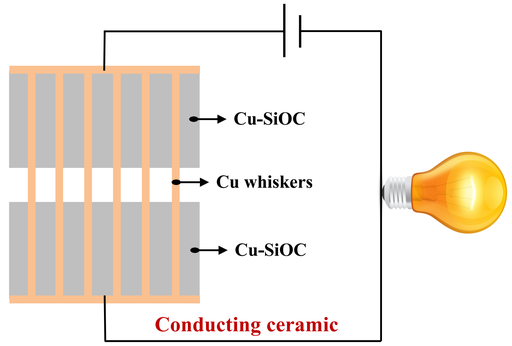




Ceramic nanowelding via in-situ growth of metal whiskers







Cu atoms in the Cu-SiOC composite diffuse to the surface of the film after annealing at low temperatures (≧ 300 °C), leading to formation of numerous nano-sized Cu particles and whiskers. The Cu whiskers penetrate the whole film and joint the two films together, which can significantly increase the conductivity of ceramic.

We provide a novel concept to achieve ceramic nanowelding, and design conducting ceramic materials via in-situ growth of metal whiskers.

This work was supported by Nebraska Center for Energy Sciences Research at the University of Nebraska-Lincoln.