Aluminium nanopillars reduce thermal conductivity of silicon nanobeams

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Reducing the thermal conductivity of a material while maintaining its high electrical conductivity is a classical dilemma of thermoelectrics. For instance, while creating nano-pores in thin membranes reduces thermal conductivity of the membranes, this also reduces the electrical conductivity, so that the overall enhancement of thermoelectric performance remains moderate. One strategy to overcome this difficulty is to change the exterior rather than the interior of nanostructures.

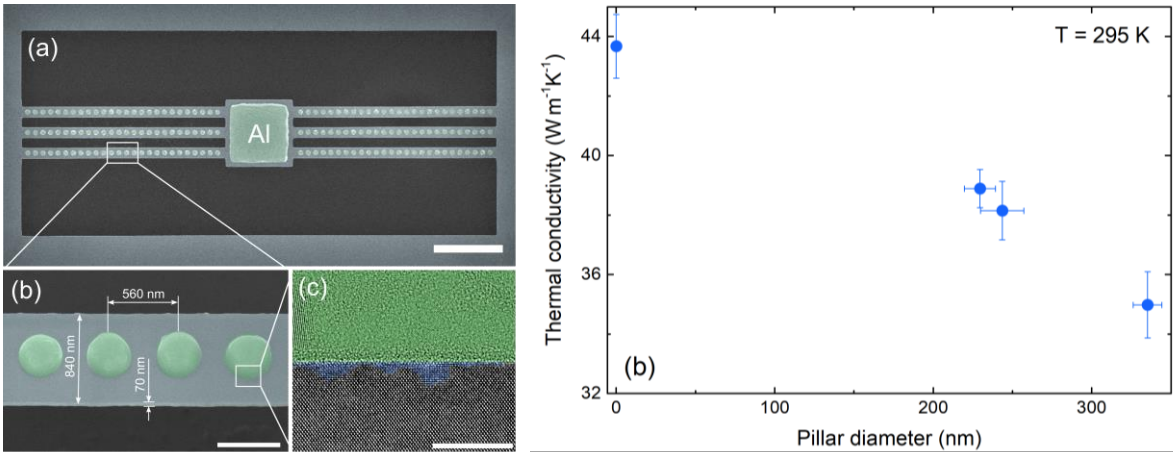

Fig. 1. SEM images of (a) a sample and (b) a nanobeam segment. (c) TEM image of aluminium/silicon interface with amorphous regions indicated by blue colour. Scale bars are (a) 5 µm, (b) 500 nm and (c) 10 nm. (d) Thermal conductivity of nanobeams as a function of pillar diameter at 295 K.

Here, we measured the in-plane thermal conductivity of silicon nanobeams with arrays of aluminium nanopillars on the surface (Fig. 1a-b) and found that the pillars reduce the thermal conductivity of the µnanobeams by 20 % at room temperature (Fig. 1d). We attributed the reduction in thermal conductivity to the diffuse phonon scattering at the pillar/beam interfaces. Our TEM observations confirmed that intermixing of the aluminium and silicon atoms results in the amorphization of the surface underneath the pillars (Fig 1c). Although such interface defects reduce thermal conductivity, they should not reduce electrical conductivity, but on the contrary may even enhance it by the presence on metal. Thus, we believe that this method is promising for thermoelectric applications. Moreover, unlike some of the conventional methods of thermal conductivity reduction, our method affects only the exterior of the structure and thus does not require sacrificing mechanical strength of the structure and generated electric power.

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References

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