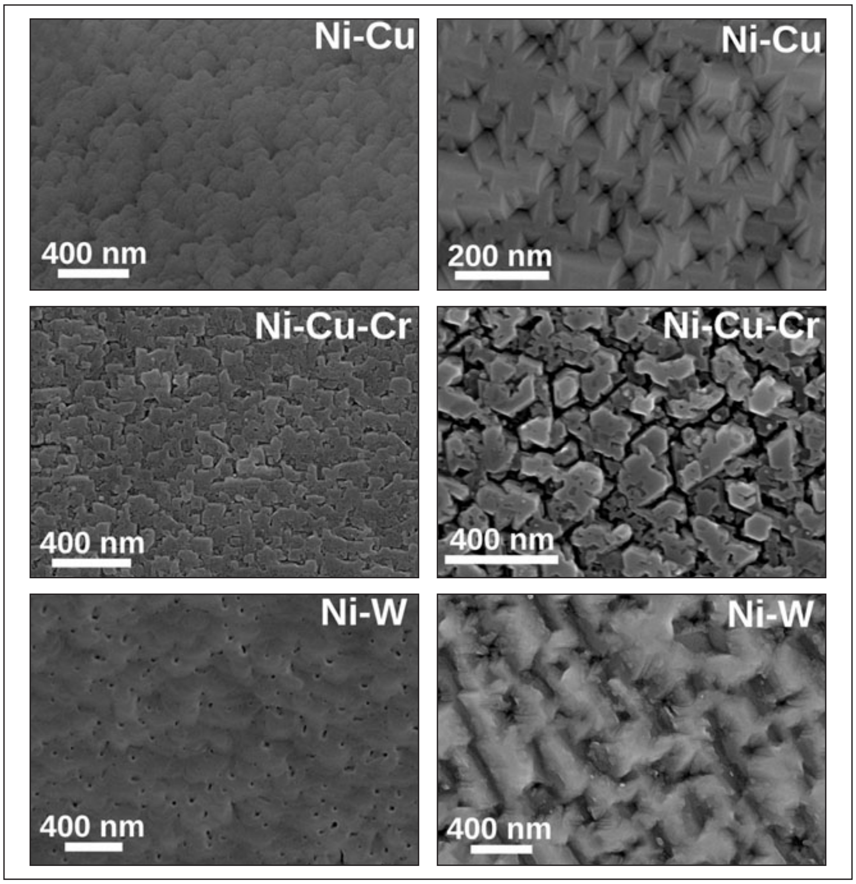
layers of metals on a diamond belongs to Nikolay Suetin [of Lomonosov Moscow State University].” This “flip” allowed the use of magnetron sputtering, a commercially available and economical technique. But growing ultrathin high-quality solid metal films on diamond presented other challenges.

Due to its chemical stability, metal adhesion to diamond tends to be poor. One solution is to form a metal carbide, although these often have undesirable properties. Iridium adheres to diamond without forming a carbide, but Evlashin and his team found that their iridium films were of poor quality—strain caused by the large mismatch between the film and substrate lattices ruined the film. Roman Khmelnitsky (RAS) suggested nickel-based alloys, which have a lattice parameter that is nearly identical to that of diamond, thereby solving the mismatch problem. They hoped that heteroepitaxy would provide sufficient adhesion. These alloys also should not form carbides at the relatively low growth temperatures. With a few carefully chosen Ni-Cu alloys, Evlashin and his colleagues grew and characterized several films.

“The big surprise was that heteroepitaxy had been achieved at a temperature of 290°C, and the parameters of the crystal lattice of [the diamond substrate] and the films differed by less than 0.5%,” Evlashin says. They had achieved high-quality, ultrathin heteroepitaxial films at a much lower temperature than expected. Furthermore, the combination of magnetron sputtering and low deposition temperature reduced fabrication costs dramatically, which is encouraging for future work. And the 0.5% mismatch is especially good—“It’s a record,” Evlashin says.

The vitality of diamond electronics depends on the ability to create durable and effective metal contacts on diamond. But this work also has applications in radiation sensing, and may have impact as far reaching as nanophotonics and quantum computing. Evlashin and colleagues have opened the door to a new avenue of research and discovery in electronic materials.

Antonio Cruz



Scanning electron micrographs of heteroepitaxial films on diamond. Credit: *Crystal Growth & Design.*

Thermoelectric power of texture revealed in SnSe

The thermoelectric materials community has recently been turning its attention to tin selenide (SnSe), whose thermoelectric properties were generally overlooked until a record value of 2.6 for the thermoelectric figure of merit *ZT*, the parameter expressing the efficiency of heat-to-electricity conversion, was recorded in a SnSe single crystal (*Nature*, doi:10.1038/nature13184). This outstanding result was associated with structural anisotropy and the strongly anharmonic bonding that together yield an ultralow intrinsic thermal conductivity. That SnSe comprises abundant and environmentally friendly elements has further motivated the study of polycrystalline SnSe, which is better suited to industrial scale-up than single crystals.

Doping and texturing have been exploited to improve the performance of polycrystalline SnSe, but early results suffered from uncertainty and failed to deliver $ZT > 1$. In a recent report in the *Journal of Materials Chemistry C* (doi:10.1039/c6tc00204h), a team of researchers from Scotland and France have further explored the impact of texturing on the thermoelectric behavior, revealing how small regions of structural disorder dramatically affect the thermal conductivity of SnSe samples. “The optimization of the thermoelectric performance is already challenging for nominally isotropic materials, but is of even greater complexity in materials such as SnSe, where texturing

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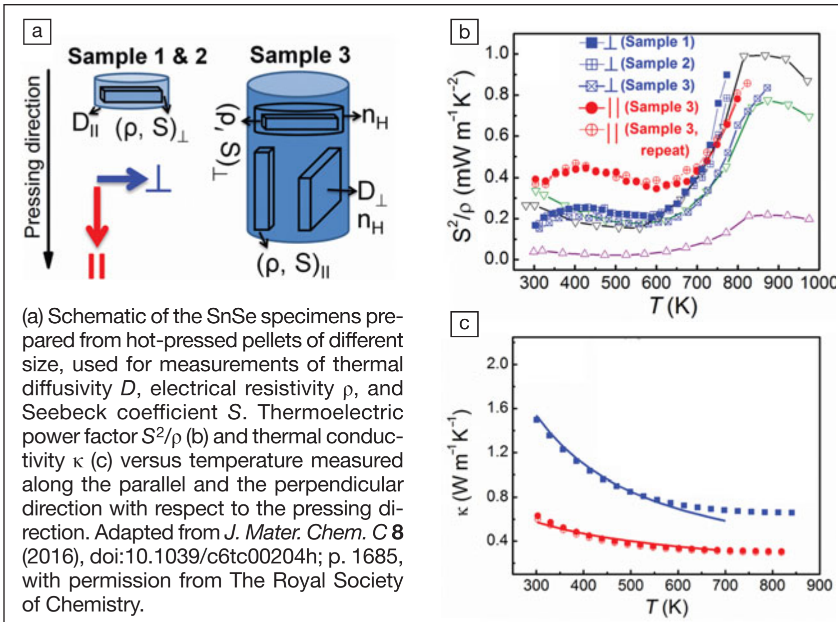
is an extra degree of freedom," says Jan-Willem Bos from Heriot-Watt University, UK, senior author of the study.

Employing a solid-state reaction and hot-pressing, the team prepared polycrystalline pellets whose core consisted of SnSe platelets oriented at 45°, while the external regions showed increasing disorder and domains of platelets oriented perpendicular to the pressing direction. The low electrical resistivity, combined with a moderate Seebeck coefficient, yielded a power factor close to the value reported for single crystals. The researchers calculated the thermal conductivity (κ) from measurements of thermal diffusivity and heat capacity. They found that κ parallel to the pressing direction, in samples that included the boundary regions, was appreciably lower (0.6 W m^{-1} K^{-1}) than that along the perpendicular direction in core specimens (1.5 W m^{-1} K^{-1}). The researchers ascribed the decrease in thermal conductivity to the contribution of point-defect scattering occurring in the boundary regions. "Our work suggests that an additional point-defect phonon scattering mechanism can be switched on by control of the microstructure," Bos says. "This additional scattering may be present to different extents in different samples, depending on processing, and may help explain the observed discrepancies in the literature."

Unfortunately, the researchers could not measure *ZT* in the parallel direction for the inhomogeneous samples due to the small size of the pellets. This will be their next step. "We want to investigate if the direction of low thermal conductivity can be united with the direction of large power factors, and enhance the figure of merit above 1 in polycrystalline SnSe," Bos says.

Although many issues still remain, SnSe provides the thermoelectric community with exciting opportunities. Olivier Delaire, a professor at Duke University, recently observed that looking at other materials with a similar complex and highly anisotropic crystal structure could prompt interesting discoveries in the field. Delaire further comments, "It's been difficult over the years to find good thermoelectric materials but SnSe is interesting in that it's not an optimization of any traditional thermoelectric compound: although the compound was known before, the fact that we just realized its great potential as a thermoelectric material tells us that there might be other materials that we just haven't thought of as thermoelectrics, but which could be, indeed, good ones."

Valentina Naglieri



(a) Schematic of the SnSe specimens prepared from hot-pressed pellets of different size, used for measurements of thermal diffusivity *D*, electrical resistivity ρ, and Seebeck coefficient *S*. Thermoelectric power factor S^2/ρ (b) and thermal conductivity κ (c) versus temperature measured along the parallel and the perpendicular direction with respect to the pressing direction. Adapted from *J. Mater. Chem. C* **8** (2016), doi:10.1039/c6tc00204h; p. 1685, with permission from The Royal Society of Chemistry.

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