# Strain tuning in microstructured quantum materials

F. Henßler[1], C. Putzke[2], S. Khim[3], A.P. Mackenzie[3], P.J.W. Moll[2], M. Le Tacon[1]

[1] Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany

[2] Max Planck Institute for the Structure and Dynamics of Matter, 22761 Hamburg, Germany

[3] Physics of Quantum Materials Department, Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

E-Mail: fabian.henssler@kit.edu

The application of strain to quantum materials is a powerful technique for tuning electronic correlations and the balance between interaction parameters by favoring specific electronic phases over almost degenerate competing orders via breaking underlying crystal symmetries. For example, it can promote a long-range charge-ordered state over high-temperature superconductivity in cuprates [1,2] or induce a chiral state in Kagome metals [3].

To maximize surface strains, we exploit the enhanced yield strain of micron-scale materials, well-studied in materials science [4]. State-of-the-art microfabrication using focused ion beam techniques allow precise design of crystalline samples, achieving desired strain fields such as uniaxial stress or more complex strain gradients [5]. We microcarve the entire sample into a flexible cantilever without a substrate and then bend it, enabling arbitrary and especially out-of-plane tensile strain even in layered quantum materials [6].

Raman scattering directly probes long-wavelength phonon modes, which are highly sensitive to lattice strain. With submicrometer spatial resolution, it provides a direct measure of strain variations. It also detects local symmetry breaking and gives access to electronic, magnetic, and orbital excitations, probing the electronic ground state. Even without a change in lattice symmetry under stress, the phonon mode frequency serves as an extremely sensitive probe, determined with high energy resolution.

The layered crystal structure of delafossite $PdCoO_2$, with weak interlayer coupling, makes it an ideal candidate for studying out-of-plane tensile strain. Its exceptional purity [7] minimizes extrinsic disorder effects. Among the various Raman modes allowed by group theory, the fully symmetric $A_{1g}$ phonon, consisting of oxygen ion vibrations along the c-direction [8], is particularly interesting. Finite element simulations guide the design of a cantilever manufactured from high-quality single crystals of $PdCoO_2$. Together with DFT-calculations our Micro-Raman measurements confirm quantitively the spatial strain distribution on the cantilever. Furthermore, we investigate the role of the amorphous layer thickness for Raman spectra.

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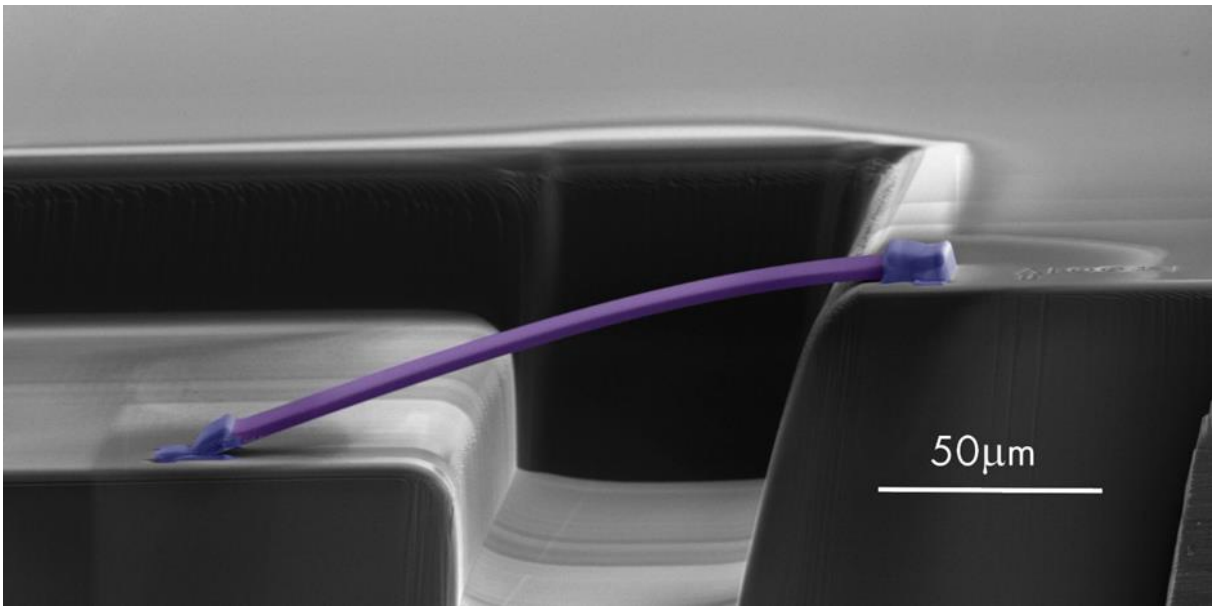


Figure 1: False color scanning electron microscopy image of a bent $PdCoO_2$ sample. The sample (purple) is mounted on a pre-structured Si-substrate (grey) and fixed by in-situ focused ion beam gas-assisted deposition of platinum (blue).