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Optimization of materials for quantum computing technologies

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The biggest roadblock towards the experimental realization of a universal, fault-tolerant quantum computer – the holy grail of quantum computation – is the limited coherence time of superconducting qubits. Recent breakthroughs have highlighted the prominent role played by the defect-prone native surface oxide layers in limiting the coherence time. However, very little is known about the nature of the defects and their mechanism of coupling to the qubit degree of freedom, in part due to the lack of suitable probes for defects in thin amorphous layers. Here, we report on the combined use of microscopy and synchrotron-based X-ray probes to investigate the surface and bulk electronic, structural and morphological properties of metal thin films used in the fabrication of superconducting qubits. We discuss correlations between these properties and relaxation times measured on transmon qubits made from the same films, and the benefits of a systematic iterative process between materials characterization and qubit measurements.