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**Substrate design guidelines for stretchable thin-film electronics**

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Electronic device materials and stretchable substrates are mechanically incompatible. Here we propose a generic design for engineered stretchable substrate, which can guarantee nearly no elongation at the device location when overall the substrate is reversibly deformed. The substrate is formed of silicone rubber with embedded, localized, stiff (non deformable) regions. The surface of the engineered substrate is planar and smooth, providing a uniform interface onto which device materials can be processed directly.

The engineered substrate is prepared using the following steps: stiff, SU8 platforms are first lithographically patterned on a silicon wafer then embedded within a matrix of PDMS rubber. After curing of the silicone elastomer, the substrate with embedded SU8 platforms is lifted-off the wafer. The geometry and density of the SU8 platforms are optimized for a given substrate thickness using finite element modeling (FEM) so that the strain in the regions above the SU8 platforms remains below 0.5%, even when macroscopic strain of 20% is applied. Experimental strain maps recorded at the surface of the engineered substrate using digital image correlation (DIC) confirm our model.

To demonstrate our approach, thin, brittle Alumina (Al2O3) disks are evaporated on bare PDMS and on engineered substrate (the alumina is film is patterned immediately above the rigid platforms), and interconnected with stretchable thin gold conductors. Catastrophic cracking occurs at low strain (<1%) in the alumina film on bare PDMS. No cracks are observed across the Al2O3 disks on engineered substrate, even when cyclically stretched to 20% total strain. The stretchable gold interconnects remain electrically stable over 100 cycles, and no mechanical failure occurs.

Engineered elastomeric substrates with in situ strain minimization offer a promising approach for the direct integration of active electronic devices onto stretchable substrates.