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LARGE SCALE THICK FILM METALLIZATION OF PDMS ENABLING FLEXIBLE ELECTRONICS IN SPACE APPLICATIONS

Abstract

Flexible electronics is an emerging technology enabling new applications in space that cannot be fabricated using traditional rigid substrates. Although some small scale flexible devices have been demonstrated on earth, for example in wearable monitoring devices, flexible sensors, and implantable neural or muscular stimulators, there are many potential space-based applications which would benefit from a new large scale, low cost metallization process on flexible substrates. With this technology, large distributed electronic payloads can be deployed as a single folded layer, for example in inflatable structures, folded antennas, or flexible satellites with electronics integrated directly into the structure. Other applications include distributed sensor networks or energy harvesters which can conform to a dynamic surface such as the human body or a spacecraft. In order to overcome the challenges of complexity, scale and cost which exist in current technologies, we have developed a new microfabrication technology enabling thick film copper microstructures fully embedded in polydimethylsiloxane (PDMS) utilizing a sacrificial conductive paint transfer method. This process is relatively simple and can be used on arbitrarily large substrates while minimizing the use of specialized materials and equipment.

The process begins with the deposition of a uniform sacrificial copper paint seed layer onto a flexible substrate via airbrushing. A dry film photoresist layer is then laminated onto the seed using a hot roll laminator and patterned using photolithographic techniques. After development, the seed layer is electroplated through the photoresist mask to achieve the desired copper thickness, followed by photoresist stripping. PDMS is then spun onto the electroplated copper pattern. The substrate is baked via hotplate, releasing the electroplated copper from the seed layer and permanently embedding it into the cured PDMS without cracking or otherwise deforming. We have performed initial characterizations of the embedded copper microstructures in terms of feature size, film thickness, surface roughness, resistivity, and reliability under flexing and stretching. Initial results show that we can achieve films 25-75μm in thickness, with reliable feature sizes down to 200μm and a film resistivity of approximately 7.15$\mu\Omega$-cm. Reliability under flexing and stretching is also demonstrated. Finally, we outline several large scale space based applications which are enabled by this technology.