Flexible, Carbon-Based Ohmic Contacts for Organic Transistors

These contacts are printed using an inexpensive, low-temperature process.

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A low-temperature process for fabricating flexible, ohmic contacts for use in organic thin-film transistors (OTFTs) has been developed. Typical drain-source contact materials used previously for OTFTs include (1) vacuum-deposited noble-metal contacts and (2) solution-deposited intrinsically conducting molecular or polymeric contacts. Both of these approaches, however, have serious drawbacks.

Use of vacuum-deposited noble-metal contacts (such as gold or platinum) obviates one of the main benefits of organic electronics, which is low-cost processing based on solution or printing techniques. First, it requires the use of vacuum-deposition techniques (such as sputtering or evaporation) instead of the less expensive solution-based processes such as spin coating, casting, or printing. Second, the use of gold or platinum for coating large-area devices is potentially expensive (both from a standpoint of materials and processing equipment). Again, this approach runs counter to the perceived low-cost benefit of organic electronics. Furthermore, adhesion of gold to many organic materials is very poor. Some recent work has been carried out regarding intrinsically conducting molecular- or polymeric-based contacts such as polyaniline and TTF-TCNQ. Unfortunately, these materials tend to exhibit high resistivities and poor overall performance, are prone to reaction with the surrounding environment, and are potentially unstable with time.

To achieve an ohmic contact to the organic semiconductor, the work function of the contact should be well matched to that of the semiconductor. Due to the similar chemical nature of the graphite filler to the conjugated poly(3-hexylthiophene) (P3HT) polymer, it was surmised that a carbon paste may possess a similar work function and therefore behave as suitable ohmic contact in this application.

To demonstrate the effectiveness of this approach, bottom contact thin-film transistors were fabricated (Fig. 1). A highly doped silicon wafer was used as the substrate, with a thermally grown 300-nm oxide gate dielectric layer. In this case, a 5-mil (127-μm) thick laser-cut stainless-steel stencil was used to pattern the contacts.

The carbon-based conductor used was a paste comprising a stable, flexible polymer binder and a conducting graphite/carbon-based filler. The
GaAs QWIP Array Containing More Than a Million Pixels

GaAs offers advantages over InSb and HgCdTe.

A 1,024 × 1,024-pixel array of quantum-well infrared photodetectors (QWIPs) has been built on a 1.8 × 1.8-cm GaAs chip. In tests, the array was found to perform well in detecting images at wavelengths from 8 to 9 µm in operation at temperatures between 60 and 70 K. The largest-format QWIP prior array that performed successfully in tests contained 512 × 640 pixels.

There is continuing development effort directed toward satisfying actual and anticipated demands to increase numbers of pixels and pixel sizes in order to increase the imaging resolution of infrared photodetector arrays. A 1,024 × 1,024-pixel and even larger formats have been achieved in the InSb and HgCdTe material systems, but photodetector arrays in these material systems are very expensive and manufactured by fewer than half a dozen large companies. In contrast, GaAs-photodetector-array technology is very mature, and photodetectors in the GaAs material system can be readily manufactured by a wide range of industrial technologists, by universities, and government laboratories.

There is much similarity between processing in the GaAs industry and processing in the pervasive silicon industry. With respect to yield and cost, the performance of GaAs technology substantially exceeds that of InSb and HgCdTe technologies. In addition, GaAs detectors can be designed to respond to any portion of the wavelength range from 3 to about 16 µm — a feature that is very desirable for infrared imaging. GaAs QWIP arrays, like the present one, have potential for use as imaging sensors in infrared measuring instruments, infrared medical imaging systems, and infrared cameras.

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Figure 2. These Current-Versus-Voltage Curves, obtained from measurements on a device like that of Figure 1, are characteristic of a field-effect transistor.