Organic Photodiodes Deposited on Newspaper

Organic semiconductors have received significant interest recently and are under serious consideration for use in flexible electronics on a wide variety of substrates. In particular, organic photodiodes have seen rapid improvements in properties and performance. In a recent study, B. Lamprecht and co-workers at Günther Leising's Institute of Nanostructured Material and Photonics in Weiz, Austria, a division of Joanneum Research, have demonstrated the fabrication and characterization of organic photodiodes deposited on ordinary newspaper sheets. They reported their results in the April issue of *Physica Status Solidi A* (p. R50; DOI: 10.1002/pssa.200510010).

The paper samples, taken from the German newspaper *Die Zeit*, were mounted on glass substrates during the fabrication process. The newspaper substrates were coated with a parylene C barrier layer (5–10 μm thick), which is an effective chemical and moisture barrier. Since the newspaper surface is rough, and the parylene coating does not provide a smoothing effect, an ORMOCER coating, which is a new class of silicate-based inorganic–organic hybrid polymer materials, was applied. The ORMOCER coating, ~100 μm thick, provided surface planarization and was inert to subsequent depositions of metal and organic layers. The rms surface roughness at this point was less than 3 nm. The organic charge-generating layers were then deposited, sandwiched between a 55-nm-thick gold bottom electrode and a 25-nm-thick semitransparent silver top electrode. The fabricated organic photodiode, similar to the well-understood Tang-type *pn*-heterojunction device, consisted of a *p*-type conducting copper phthalocyanine (CuPc) and an *n*-type perylene tetracarboxylic bisbenzimidazole. The organic and metal layers were deposited using room-temperature, high-vacuum sublimation. The fabricated devices were removed from the glass substrates prior to characterization.

The current–voltage characteristics of the devices were measured in the dark and under illumination using a halogen lamp, with white light passing through the semitransparent Ag electrode. In the dark, the devices showed a well-pronounced rectification ratio of about 10^4 at ±1 V. On illumination, the devices yielded a photocurrent exceeding the dark current by about six orders of magnitude when operated near a zero bias condition. No hysteresis effect was observed. The photodiodes yielded very good diode behavior. Also, in order to determine the spectral response of the device, measurements of spectrally resolved external quantum efficiency were carried out using a tungsten halogen lamp and a monochromator. The devices yielded a spectral response covering the complete ultraviolet and visible light range. The researchers said that although newspaper was used as an example, from a wider perspective, this study demonstrated that organic photodiode devices may likely be fabricated on almost any user-defined substrate.

GOPAL RAO

Al-Based Tunnel Junctions Form Solid-State Refrigerator Suitable for Sub-Kelvin Applications

Many cutting-edge analytical and astronomical devices require cryogenic operating temperatures of ~100 mK. Current methods for chilling to the 0.1 K range, such as adiabatic demagnetization refrigerators (ADR), can be costly and impractical. As an alternative, A.M. Clark and N.A. Miller of the National Institute of Standards and Technology (NIST), along with co-workers from NIST and the University of Notre Dame, have demonstrated a solid-state refrigerator based on normal metal–insulator–superconductor (NIS) junctions composed of Al and Al-Mn electrodes. The refrigerator has limited cooling capacity, but is suitable for critical applications in which a primary refrigerator or liquid cryogen cools a device to subkelvin temperatures, and the solid-state refrigerator provides a secondary cooling source to pull a device below a critical temperature. As reported in the April 25 issue of *Applied Physics Letters* (173508; DOI 10.1063/1.1914966), the devices can effectively cool large-area Si_3N_4 membranes as well as electrically isolated bulk payloads placed on the membrane.

The NIS refrigerators (see Figure 1) are fabricated using typical thin-film lithography processes, making them easy to integrate with other solid-state devices. The refrigerators are designed with pure Al as the superconductor, Al doped with Mn as the normal metal, and an Al-Mn oxide as the insulator. Four pairs of 25 μm × 15 μm NIS junctions surround a 450 μm × 450 μm Si_3N_4 membrane formed by deep reactive ion etching. Al-Mn cold fingers extend from the refrigerator junctions onto the edges of the suspended membrane, and perforations isolate the fingers and membrane from the substrate. The fingers and membrane are coated with separate Au films to enhance thermal conductivity. Additional NIS junctions (5 μm × 5 μm) were incorporated as temperature sensors. When the refrigerator junctions are under bias, the hottest (highest energy) electrons tunnel from the normal metal fingers away into the superconducting metal. The very low phonon thermal conductance (compared to electron or electron–phonon) allows the entire membrane to be cooled by the cold fingers.

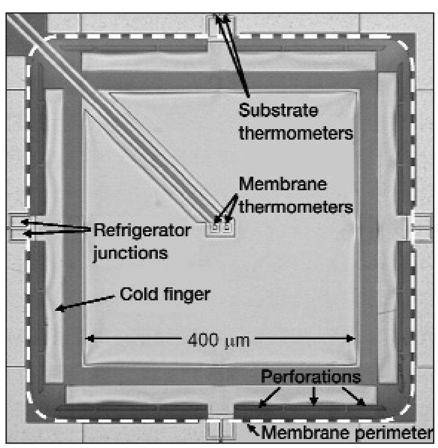

Figure 1. Optical micrograph of metal–insulator–superconductor refrigerator.

The researchers used an ADR to chill the devices for calibration and characterization. At an optimal applied bias of 0.91 Δ/e, where Δ = 189 μeV is the superconducting bandgap energy, the devices were able to reduce the membrane temperature from a starting point of 320 mK to 225 mK and from a starting point of 260 mK to 175 mK. The refrigerators were able to cool a 250 μm cube of doped Ge placed on the membrane from 320 mK to ~240 mK. The cooling power is 40–80 pW, which is sufficient to cool five cryogenic photon sensors without raising the temperature of the cold fingers by more than 5 mK. The researchers are working to further improve performance by better heat-sinking of the superconductor and developing a normal metal with a higher thermal conductivity than the Al-Mn. The researchers also indicated that multistage designs should be easy to fabricate and indicated that a three-stage design should be able to cool objects from an initial temperature of 500 mK to ~10 mK.

AMANDA GIERMANN

Gold Nanoshell Bioconjugates Used for Molecular Imaging in Living Cells

Optical imaging is playing a dramatic role in cancer therapy by aiding early detection, critical to reducing mortality rates. Optical imaging of molecular-specific contrast agents offers real-time *in vivo* monitoring of abnormalities before pathologic changes occur on the atomic level. In the May 1 issue of *Optic Letters* (p. 1012), C. Loo, R. Drezek, N. Halas, and co-workers from Rice University described how