New Organic Resonant Tunneling Diode (ORTD) and Related Devices

Patent Title:	HYBRID ORGANIC/NANOPARTICLE DEVICES
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This invention provides a new method for fabricating Organic Resonant Tunneling Diode (ORTD) whereby the devices fabricated are more stable and exhibit enhanced PVCR and OLED characteristics.

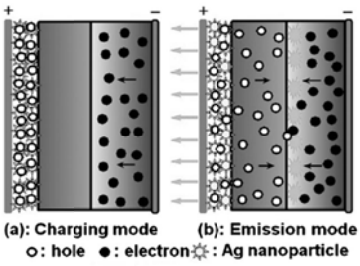
Market Opportunity

Current applications of Resonant Tunneling Diodes (RTDs) with advanced conventional transistors have shown that RTDs are very promising for future ultra-high-speed digital devices. Organic Resonant Tunneling Diodes (ORTDs) may lead to improved printed memory, analog oscillators and RTD based circuits.

Printed memory platforms (such as smart cards, games, sensors, displays, and storage-class memory networks) contribute to the printed electronics market by a large ratio. As reported by NanoMarkets [1], the printed memory market has been growing at a fast rate since 2005 and reached more than US$ 10 billion in 2010. In addition, ORTDs are critical for the market of micro-electro-mechanical system (MEMS). According to a Yole Development report, "Emerging MEMS: Technologies & Market, 2010 Report", the MEMS market will reach around US$ 20 billion by 2015.

The HKU Invention

This invention provides device-exhibiting unusual properties of ORTD at low bias voltage while maintaining OLED characteristics at high voltage. The dual behaviors can be described by two different operating stages: i) charging mode at low voltage range and ii) emission mode at high voltage range, as shown in figure(a) and figure(b) on the right.



High PVCR is an important *figure of merit* for ORTD. Under current approaches, high PVCR value is usually obtained at a lower temperature, but the line-width of the corresponding resonant peak then becomes quite broad. However, our invention is able to obtain high PVCR at room temperature while keeping a narrow line-width at resonant peak. Therefore a strong negative differential resistance behavior is demonstrated at room temperature. For example, a high peak-to-valley current ratio (PVCR) value of over 4.6 and a narrow line-width of the current resonance peak (only~1.4 V) are obtained, as shown in Device C in figure(c) and Table 1.

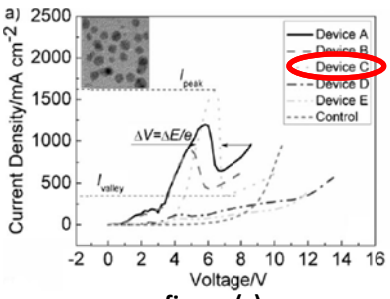


figure (c)

By combining the properties of silver nanoparticles and organic materials, hybrid devices fabricated by this new method pave the way for resonant tunneling and light emission capabilities in a single device unit.

Table 1. The dependence of resonant tunneling properties on Ag concentration in hybrid NP/organic devices

Device	I_{peak} [mA cm^{-2}]	I_{valley} [mA cm^{-2}]	PVCR	ΔV_0 [V]	Ag [mol L^{-1}]
Device A	1202.3	641.1	1.9	1.5	5×10^{-2}
Device B	889.6	429.8	2.1	1.4	2.5×10^{-2}
Device C	1615.7	351.2	4.6	1.4	1.25×10^{-2}
Device D	123.3	100.2	1.2	1.1	6.25×10^{-3}
Device E	74.6	66.1	1.1	0.8	3.125×10^{-3}

About the Lead Inventor

Wallace C. H. Choy received his PhD in Electronic Engineering from the University of Surrey, UK. He then joined the National Research Council of Canada's research staff to work on optical device structures of polarization-independent optical amplifiers and modulators. He joined Fujitsu at San Jose, US, in 2001 to develop real-time wavelength tunable lasers and optical transmitter modules. He is now an Assistant Professor of the Department of Electrical and Electronic Engineering, the University of Hong Kong.

Dr Choy's current research interests are concerned with organic optoelectronic devices and nano-material devices. He has published over 80 international technical journal papers, contributed to two book chapters, and published US patents. He was the recipient of the Sir Edward Youde Memorial Fellowship and the Croucher Foundation Fellowship. He received the Outstanding Achievement Award from National Research Council of Canada in 2001 and overseas visiting fellowships from HKU to take a sabbatical at George Malliaras's Group, Cornell University in 2008. He has been serving as a technical consultant of HK-Ulvac (a member of stock-listed Ulvac Corp) since 2005. He has delivered invited talks and served as a committee member in international industrial and academic conferences organized by various organizations such as IEEE, OSA and Plastic Electronics Foundation. He is now a senior member of IEEE.

References

[1] http://otc.nfmf.no/public/news/4321.pdf

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