Asakura *et al.* Reply: In the Comment by Hoffmann *et al.* [1], the authors pointed out the importance of the intrinsic photodoping effect in $YBa_2Cu_3O_y$ (YBCO). We agree with Hoffmann *et al.* in that the intrinsic electronic and/or chemical changes can be induced by laser illumination and can provide transient and/or persistent photodoping effects in YBCO.

First of all, in the study by Asakura *et al.* [2], a set of photoemission measurements have been performed before, during, and after laser illumination. Then this measurement cycle has been repeated many times to check the reproducibility of the energy shift. The important point of the study by Asakura *et al.* is that the energy shift of the photoemission spectra was observed only during the laser illumination and that the energy shift disappeared immediately after switching off the laser. Therefore, we can easily exclude the possibility of the persistent photodoping effect in YBCO itself. Since the laser illumination with the power of 10^5 W per pulse is intense enough to immediately cause the persistent change with the time scale of the pulse width about 10 ns, the resultant (persistent) spectral change has been completed at the first illumination of the first measurement cycle. In the second or later measurement cycles, the spectral shape was not affected by the laser illumination and only the energy shift by the photocarrier injection (PCI) effect was observed.

As for the transient photodoping effect in YBCO, the chemical potential shift due to the photoinduced carrier should be small compared to the observed energy shift due to the PCI effect. In the case of chemical doping of other related cuprate compounds, which are different from YBCO, the chemical potential shift from the underdoped antiferromagnetic sample to the optimally doped one is less than 0.4 eV [3–6]. Chemical potential shift in cuprates is common for all of the core levels except Cu $2p$, and the direction of the shift with increasing hole concentration is to the lower energy side. On the other hand, the photoemission studies referred to in the Comment by Hoffmann *et al.* [1] report chemical shift of a specific core level (Cu $2p$ or Ba $4d$) by chemical change at surface which should be distinguished from the chemical potential shift. In the measurement by Asakura *et al.*, all of the core level peaks including Cu $2p$ were shifted to the higher energy side by the laser illumination, which is opposite to the direction expected for the chemical potential shift upon hole doping. Therefore, the observed energy shift of about 1 eV should be mainly due to the photovoltage generated by the PCI effect at the interface. In conclusion, the energy shift reported by Asakura *et al.* is related to the PCI effect at the interface between YBCO and Nb-doped $SrTiO_3$ and that the photoinduced change of the YBCO film itself is comparably small if it exists.

D. Asakura,[1] J. W. Quilty,[2] K. Takubo,[1] T. Mizokawa,[1,2] Y. Muraoka,[3] and Z. Hiroi[3]
[1]Department of Physics and Department of Complexity Science and Engineering
University of Tokyo
5-1-5 Kashiwanoha Kashiwa, Chiba 277-8561, Japan
[2]PRESTO
Japan Science and Technology Agency
4-1-8 Honcho Kawaguchi, Saitama 332-0012, Japan
[3]Institute for Solid State Physics
University of Tokyo
5-1-5 Kashiwanoha Kashiwa, Chiba 277-8581, Japan

Received 16 April 2006; published 11 September 2006
DOI: 10.1103/PhysRevLett.97.119702
PACS numbers: 74.78.Bz, 73.50.Pz, 74.25.Gz, 79.60.Jv

[1] A. Hoffmann, G. Nieva, J. Guimpel, Y. Bruynseraede, J. Santamaria, D. Lederman, I. K. Schuller, preceding Comment, Phys. Rev. Lett. **97**, 119701 (2006).
[2] D. Asakura, J. W. Quilty, K. Takubo, S. Hirata, T. Mizokawa, Y. Muraoka, and Z. Hiroi, Phys. Rev. Lett. **93**, 247006 (2004).
[3] A. Ino, T. Mizokawa, A. Fujimori, K. Tamasaku, H. Eisaki, S. Uchida, T. Kimura, T. Sasagawa, and K. Kishio, Phys. Rev. Lett. **79**, 2101 (1997).
[4] N. Harima, A. Fujimori, T. Sugaya, and I. Terasaki, Phys. Rev. B **67**, 172501 (2003).
[5] H. Yagi, T. Yoshida, A. Fujimori, Y. Kohsaka, M. Misawa, T. Sasagawa, H. Takagi, M. Azuma, and M. Takano, Phys. Rev. B **73**, 172503 (2006).
[6] H. Yagi, Ph.D. thesis, University of Tokyo, 2006.

