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# TEM and Magnetic Studies of Metallic Nanoparticles in Ni-ion-implanted Rutile

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Ion implantation is one of the most powerful techniques to fabricate metal nanoparticles in the near surface of insulating substrates. Titanium dioxide ($TiO_2$) has attracted much attention because it is one of the wide band gap insulators and one of the most promising photocatalysts with high activity. Surface modification of $TiO_2$ by Cu or Ag negative ion implantation can improve photocatalytic efficiencies by approximately 1.8 times [1]. Cr ion implantation has enhanced electrical conductivity of $TiO_2$ single crystals [2]. Room temperature ferromagnetic properties of Co-doped $TiO_2$ have been reported. [3]. Nano-sized Au particles in $TiO_2$ have been synthesized by ion implantation for unusual nonlinear optical properties enhanced by surface plasmon resonance [4]. In our study, the magnetic nanoparticles of Ni embedded in $TiO_2$ single crystals have been synthesized by ion implantation, which may provide potential application of the nanocomposite as magneto-optical materials for high density magnetic data storage device.

Nanoparticles of Ni in the near surface region of $TiO_2$ single crystals have been synthesized by ion beam implantation. The Ni ion implantation was conducted at the room temperature to a fluence of $1\times10^{17}/cm^2$. Transmission electron microscopy and a MPMS superconducting quantum interference device (SQUID) magnetometer have been utilized to characterize the nanostructure of Ni particles in $TiO_2$, and the change of optical and magnetic properties. Nanopartilce of Ni with size ranging 3 - 18 nm was observed in the surface of $TiO_2$ and these nanoparticles have a specific orientation relationship with the matrix: Ni $[011]_{Ni}$ // $[010]_{TiO2}$. Magnetic measurement indicated that the coercive force of Ni nanoparticles was about 210 Oe at 10 K. The blocking temperature based on ZFC/FC curves was about 85 K.

Reference

[1] H. Tsuji et al., Surface Coating and Technology 158-159 (2002) 208.
[2] R.C. da Silva et al., Nucl. Instr. and Meth. B 191 (2002) 158.
[3] V. Shuttanandan et al., Applied Physics Letter 84 (2004) 4466.
[4] H.B. Liao et al., Applied Physics Letter 72 (1998) 1817.
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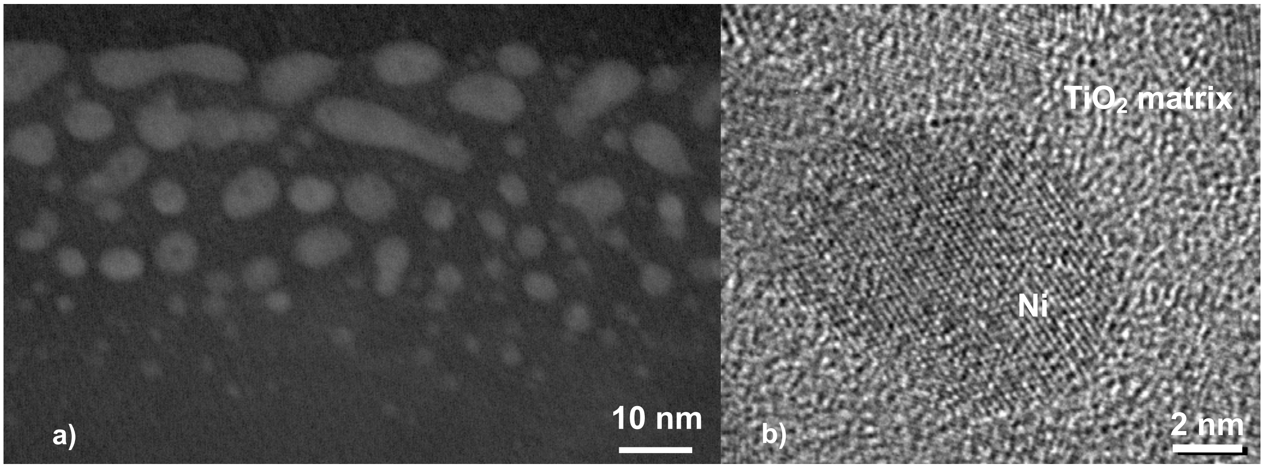


Fig. 1. A Z-contrast STEM image indicating the Ni nanoparticles in a $TiO_2$ crystal after ion implantation (a); A high resolution TEM micrographs showing crystalline characteristics of Ni nanoparticles in amorphous $TiO_2$ host which result from the implantation damage (b).

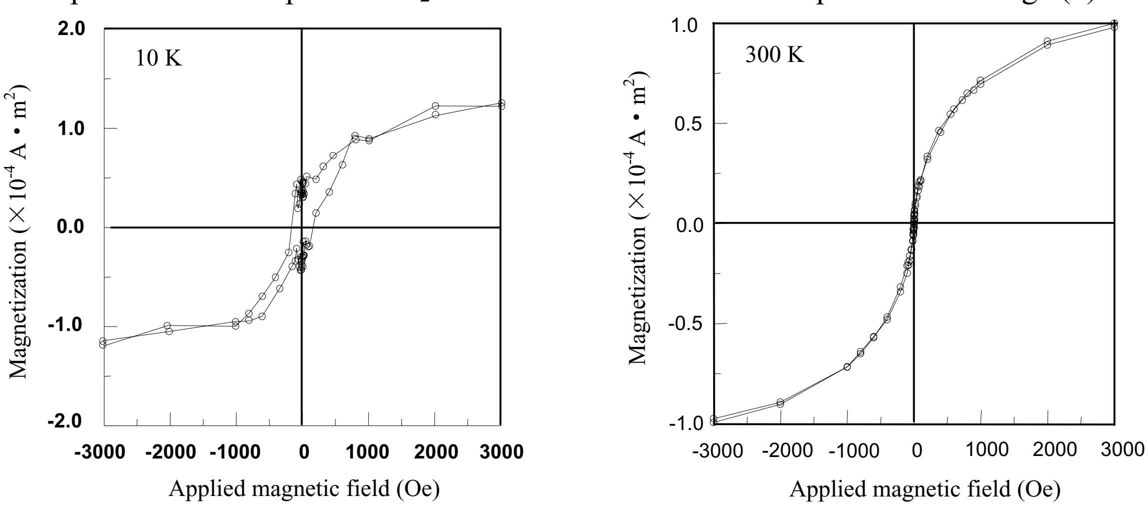


Fig. 2. Magnetic hysteresis loops of Ni nanoparticles in $TiO_2$ single crystals at 10 K and 300 K indicating the coercive force of Ni nanoparticles was about 210 Oe at 10 K.

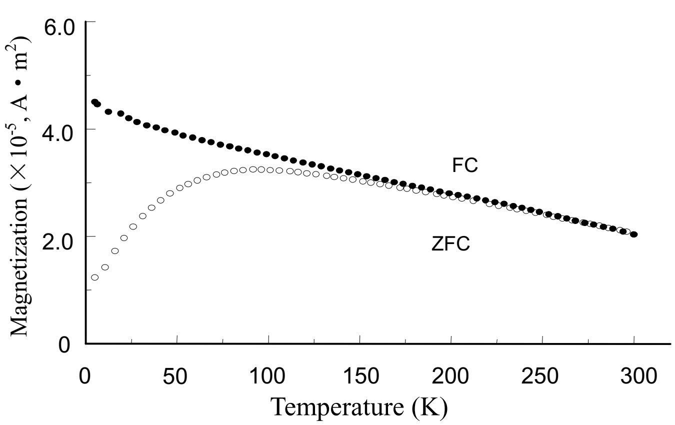


Fig. 3. Temperature dependence of the magnetization showing the $T_b = 85$ K. Curves were taken in the ZFC and FC processes at H = 100 Oe.

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