

## TEM and EDX Studies on the Structural and Compositional Evolution of PtNi<sub>3</sub> Concave Nanocubes

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It has been demonstrated that the optical, biological, and chemical properties of metal nanoparticles are highly influenced by size, composition and morphology [1]. These systems are promising candidates for a wide variety of applications in catalysis, sensing, electronics, photonics, and medicine. Pt and its alloys have been receiving a great deal of attention because of their unique catalytic properties and a wide variety of economically driven applications. Recent work on Pt<sub>3</sub>Co nanocubes [2] and Pt<sub>3</sub>Ni nanoframes [3] showed enhanced catalytic activity with a strong dependence on the structure and composition of the nanocrystals. In this work we utilize high-resolution transmission electron microscopy (HRTEM) and electron dispersive X-ray (EDX) spectroscopy to study the structural and compositional evolution of PtNi<sub>3</sub> concave nanocubes before and after annealing in order to understand the difference in their electrochemical properties. High-resolution TEM images of as prepared PtNi<sub>3</sub> concave nanotubes were observed along three representative zone axes [001], [110], and [111], and showed that the initial PtNi<sub>3</sub> concave nanocubes are fcc nanocrystals (Fig. 1 a-c), while after annealing most PtNi<sub>3</sub> concave nanocubes become hollow nanocrystals (Fig. 1 d-f). EDX elemental mapping results showed that in as prepared nanocubes, Pt forms a cubic frame and the Ni EDX map indicates that it forms a sphere located inside and outside of the Pt cubic frame (Fig. 2 a-c). After annealing, it was found that Pt-rich frame still exists but Ni EDX map shows much less Ni than initial nanocubes, and the Pt/Ni ratio after annealing is much higher than in initial nanocubes (Fig. 2 d-f). We conclude that the PtNi<sub>3</sub> concave nanocubes developed from Ni-rich nanocrystals to Pt-rich nanoframes after annealing. The detail of the structure and composition evolution of PtNi<sub>3</sub> nanocubes before and after annealing will be discussed.

### References

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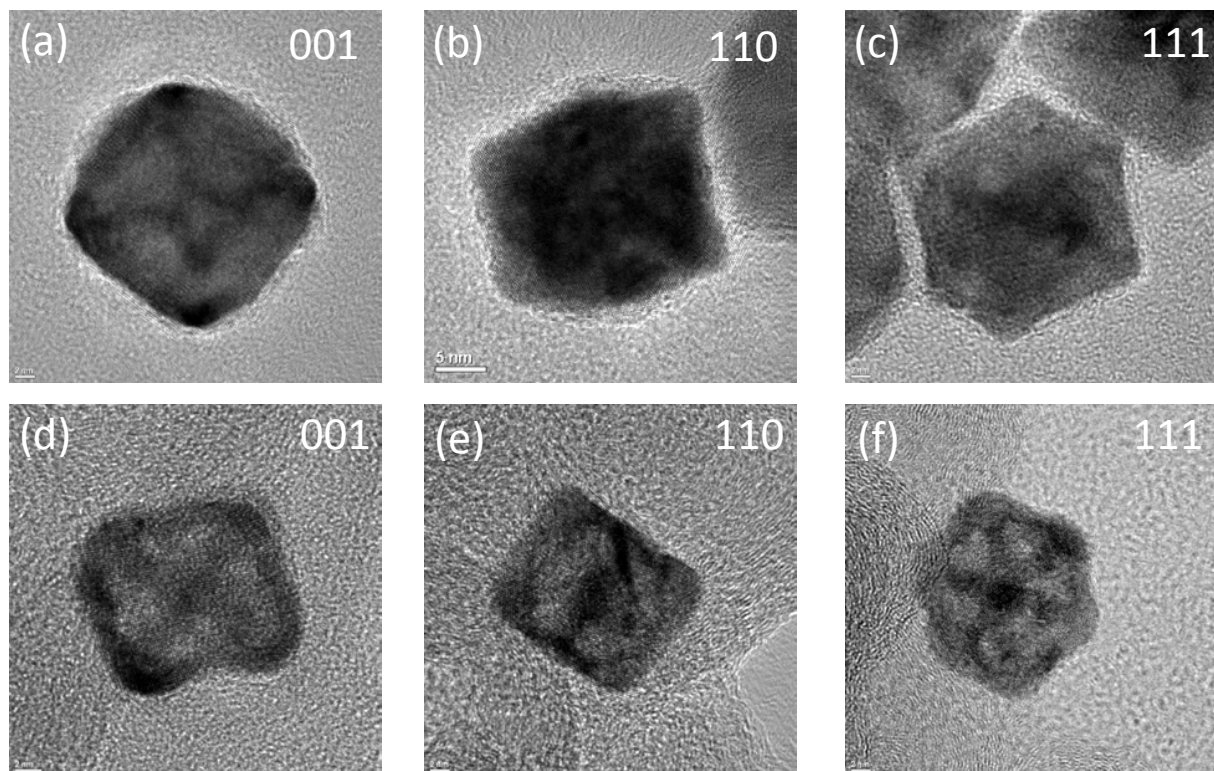


Figure.1 Bright field images from as prepared concave nanocubes (a)-(c), and from annealed nanocubes (d)-(f) along orientation [001], [110], and [111] respectively.

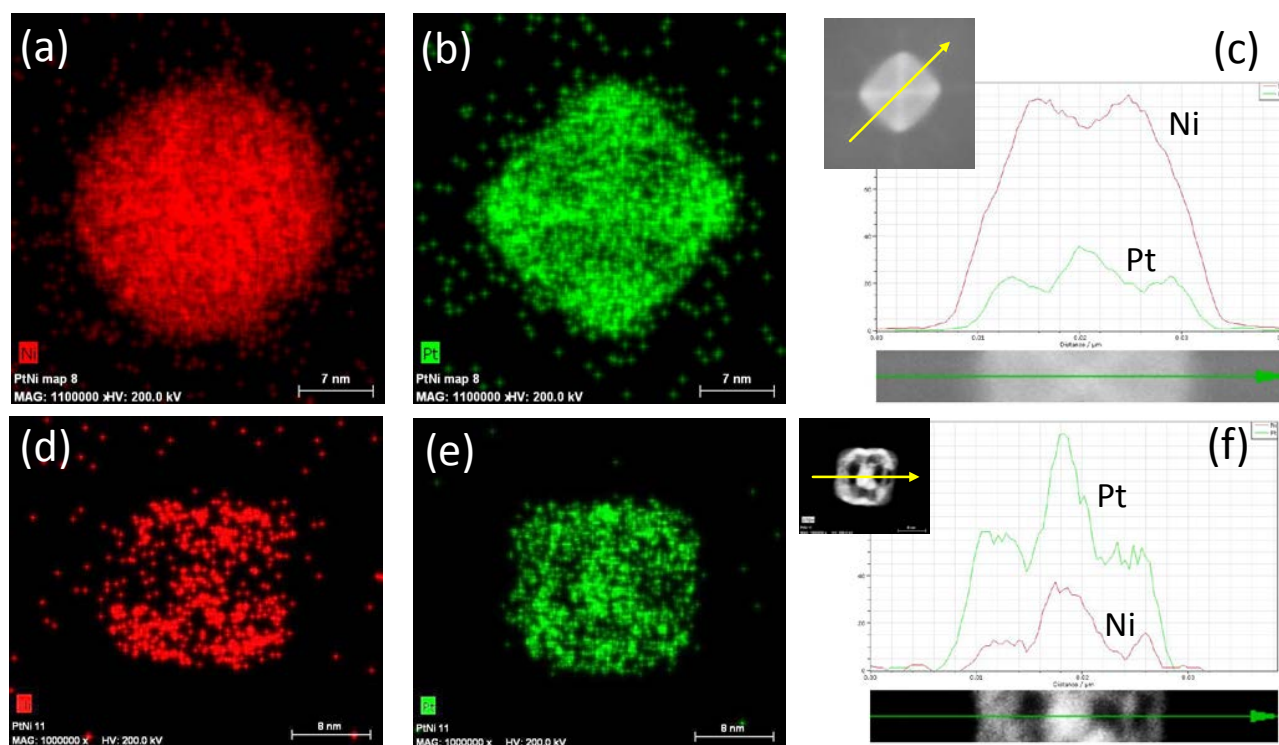


Figure.2 Elemental mapping and line scan of Ni and Pt from as prepared concave nanocube (a)-(c) and from annealed nanocube (d)-(f).