

## Supplementary Information

### Preparation of Ni nanoparticles by liquid-phase reduction to fabricate metal nanoparticle–polyimide composite films

**Daiki Fujioka**

Department of Applied Chemistry, College of Life Sciences, Ritsumeikan University, 1-1-1 Noji-Higashi,  
Kusatsu-City, Japan  
Email: rc007040@ed.ritsumeai.ac.jp Tel: +81-77-561-2780

**Shingo Ikeda**

Electronic Materials Research Division, Osaka Research Institute of Industrial Science and Technology,  
1-6-50 Morinomiya, Joto-ku, Osaka 536-8553, Japan  
Email: ikeda-s@omtri.or.jp TEL: +81-6-6963-8087

**Kensuke Akamatsu**

Department of Nanobiochemistry, Frontiers of Innovative Research in Science and Technology (FIRST),  
Konan University, 7-1-20 minatojimaminami, Chuo-ku, Kobe 650-0047, Japan  
Email: akamatsu@center.konan-u.ac.jp TEL: +81-78-303-1447

**Hidemi Nawafune**

Department of Nanobiochemistry, Frontiers of Innovative Research in Science and Technology (FIRST),  
Konan University, 7-1-20 minatojimaminami, Chuo-ku, Kobe 650-0047, Japan  
Email: nawafune@center.konan-u.ac.jp

**Kazuo Kojima**

Department of Applied Chemistry, College of Life Sciences, Ritsumeikan University, 1-1-1 Noji-Higashi,  
Kusatsu-City, Japan  
Email: kojimaka@sk.ritsumeai.ac.jp Tel: +81-77-561-2780

## Contents

1. XRD patterns of Ni-NPs/PI films without being annealed at 300 °C for 2 h in a nitrogen atmosphere
2. Cross-sectional TEM image and particle size distributions of a Ni-NPs/PI films reduced at 50 °C
3. X-ray diffraction patterns of samples subjected repeatedly to adsorption/reduction treatment of Ni<sup>2+</sup> ions
4. Cross-sectional TEM images and particle size distributions of samples repeated Ni<sup>2+</sup> ion adsorption/reduction treatment
5. Electron diffraction patterns of the samples obtained by repeated Ni<sup>2+</sup>-ion adsorption/reduction treatment
6. Comparison of X-ray diffraction patterns of fcc-Ni and Ni borides

1. XRD patterns of Ni-NPs/PI films without being annealed at 300 °C for 2 h in a nitrogen atmosphere

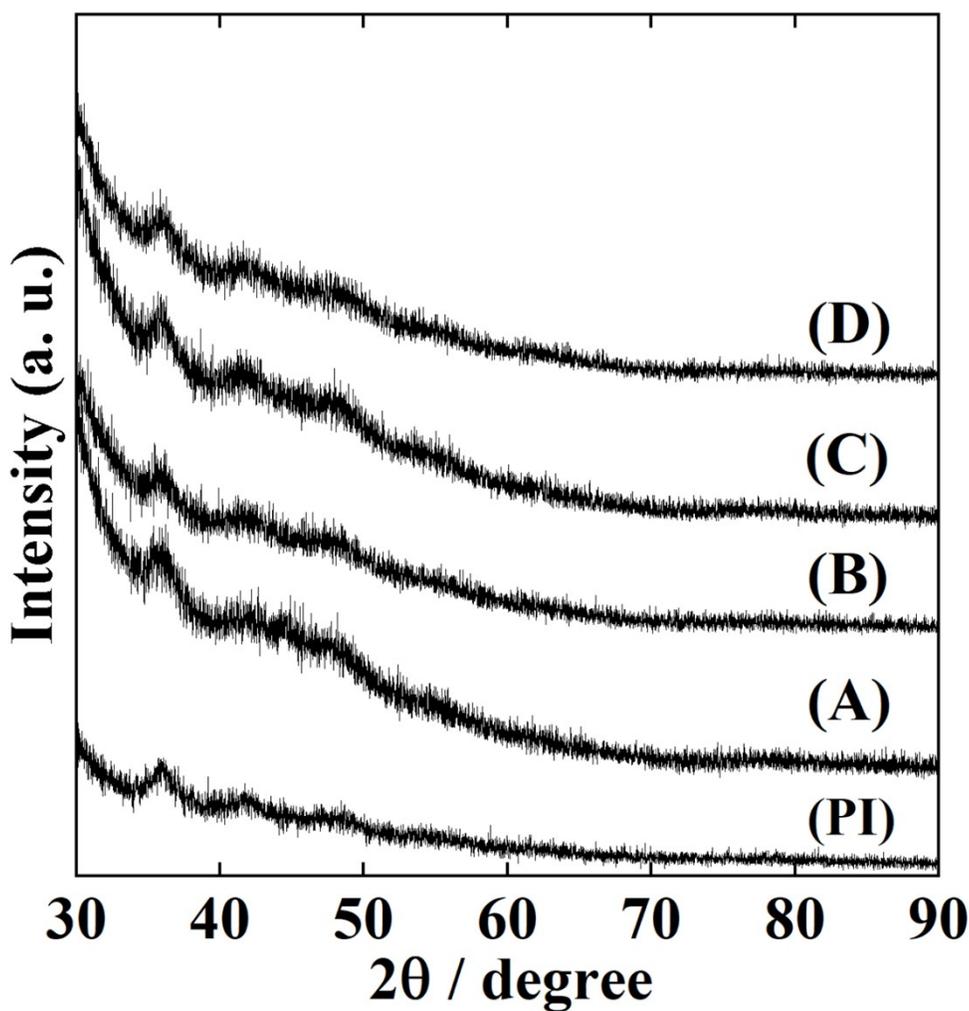


Figure S1. XRD patterns of Ni-NPs/PI films without being annealed at 300 °C for 2 h in a nitrogen atmosphere. The films were prepared by immersed polyimide film containing  $\text{Ni}^{2+}$  ions into  $\text{KBH}_4$  aqueous solutions of (A) 0.02, (B) 0.06, (C) 0.12, and (D) 0.20 mol  $\text{dm}^{-3}$ . A polyimide film without embedded nickel ions (PI) shows no nickel diffraction patterns.

2. Cross-sectional TEM image and particle size distributions of a Ni-NPs/PI films reduced at 50 °C

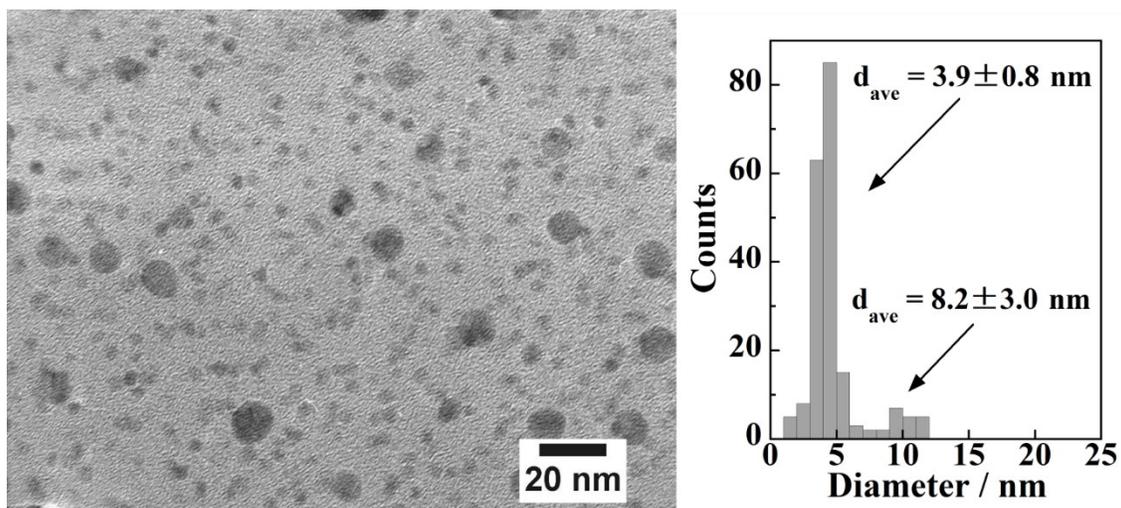


Figure S2. Cross-sectional TEM image (left) and particle size distributions (right) of a Ni-NPs/PI films reduced at 50 °C. The film was prepared by immersing Ni<sup>2+</sup>-ions containing polyimide film into KBH<sub>4</sub> aqueous solution of 0.20 mol dm<sup>-3</sup>

3. X-ray diffraction patterns of samples subjected repeatedly to adsorption/reduction treatment of  $\text{Ni}^{2+}$  ions

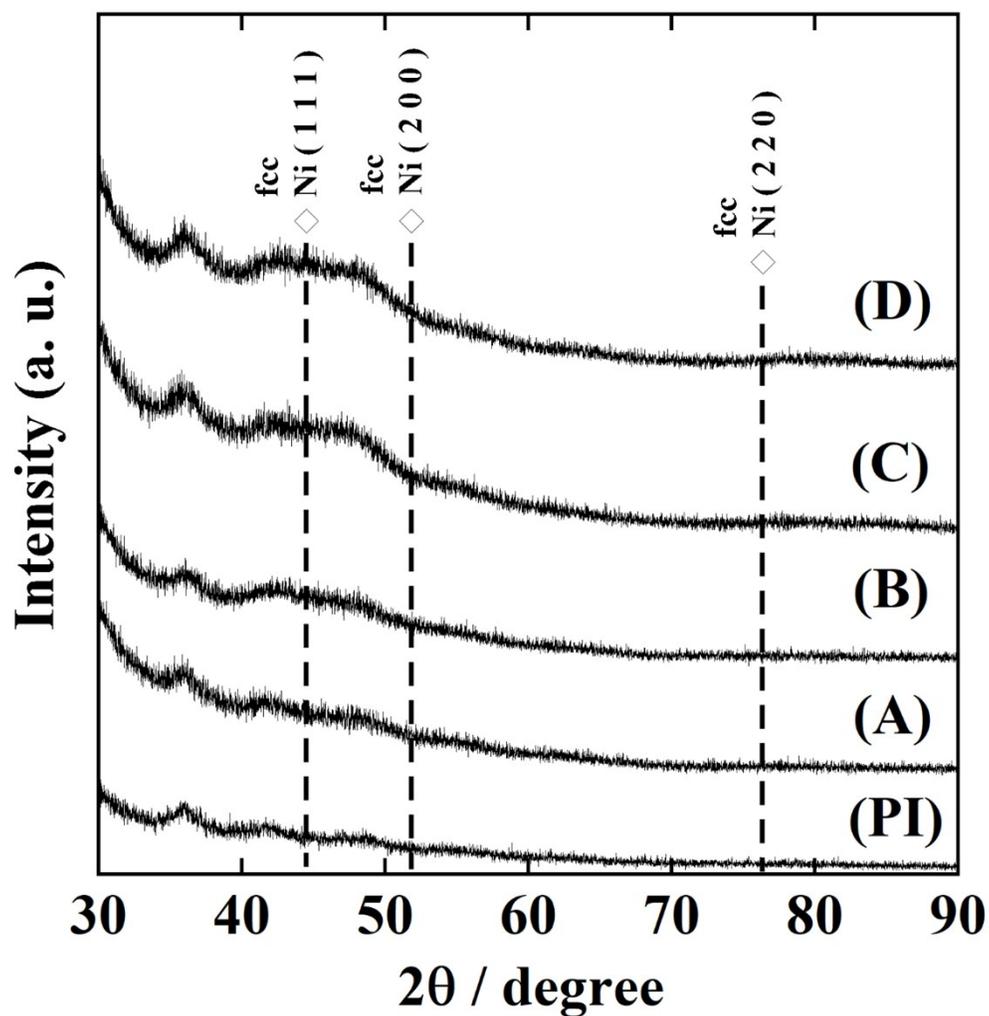


Figure S3. X-ray diffraction patterns of samples subjected repeatedly to adsorption/reduction treatment of  $\text{Ni}^{2+}$  ions: (PI) polyimide film without embedded  $\text{Ni}^{2+}$  ions, and samples repeated  $\text{Ni}^{2+}$  ion adsorption/reduction treatment for (A) one cycle, and (B) three, (C) five, and (D) seven cycles. The (PI) film shows no nickel diffraction patterns.

4. Cross-sectional TEM images and particle size distributions of samples repeated Ni<sup>2+</sup> ion adsorption/reduction treatment

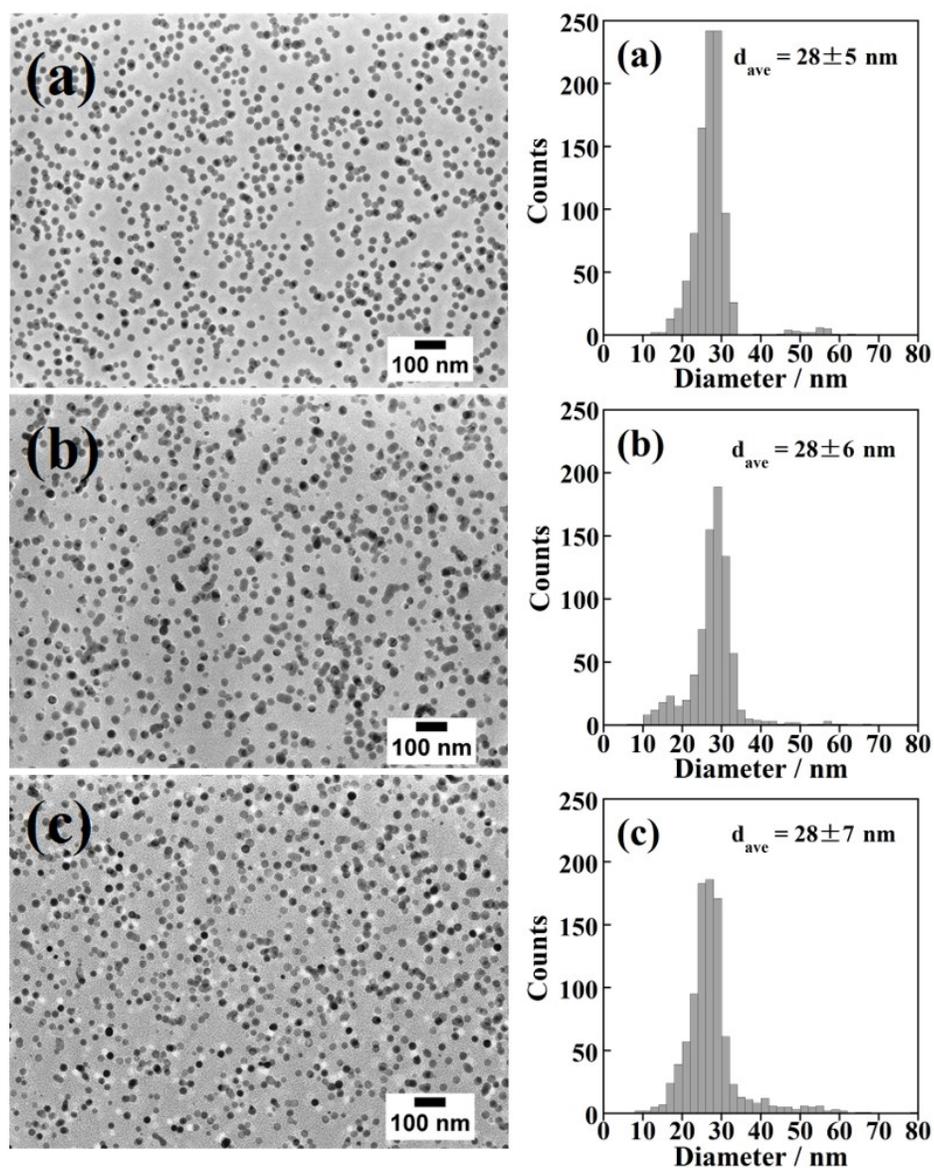


Figure S4. Cross-sectional TEM images (left) and particle size distributions (right) of samples repeated Ni<sup>2+</sup> ion adsorption/reduction treatment for (a) three, (b) five, and (c) seven cycles.

5. Electron diffraction patterns of the samples obtained by repeated Ni<sup>2+</sup>-ion adsorption/reduction treatment

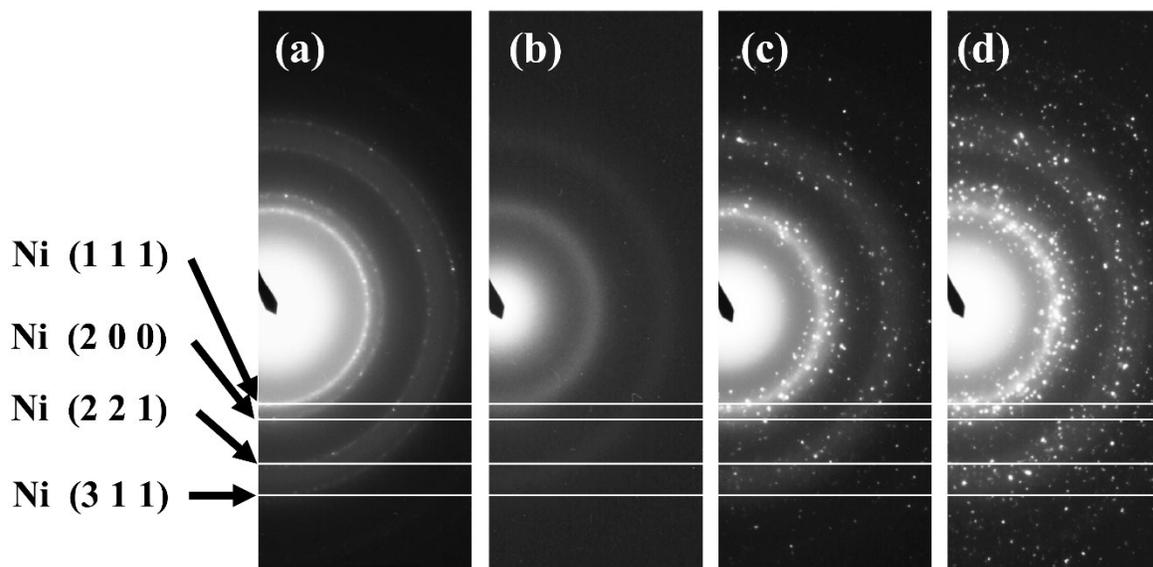


Figure S5. Electron diffraction patterns of the samples obtained by repeated Ni<sup>2+</sup>-ion adsorption/reduction treatment for (b) three, (c) five, and (d) seven cycles. A sample (a) reduced with the 0.20-mol dm<sup>-3</sup> KBH<sub>4</sub> aqueous solution at 50 °C with one repetition number.

6. Comparison of X-ray diffraction patterns of fcc-Ni and Ni borides

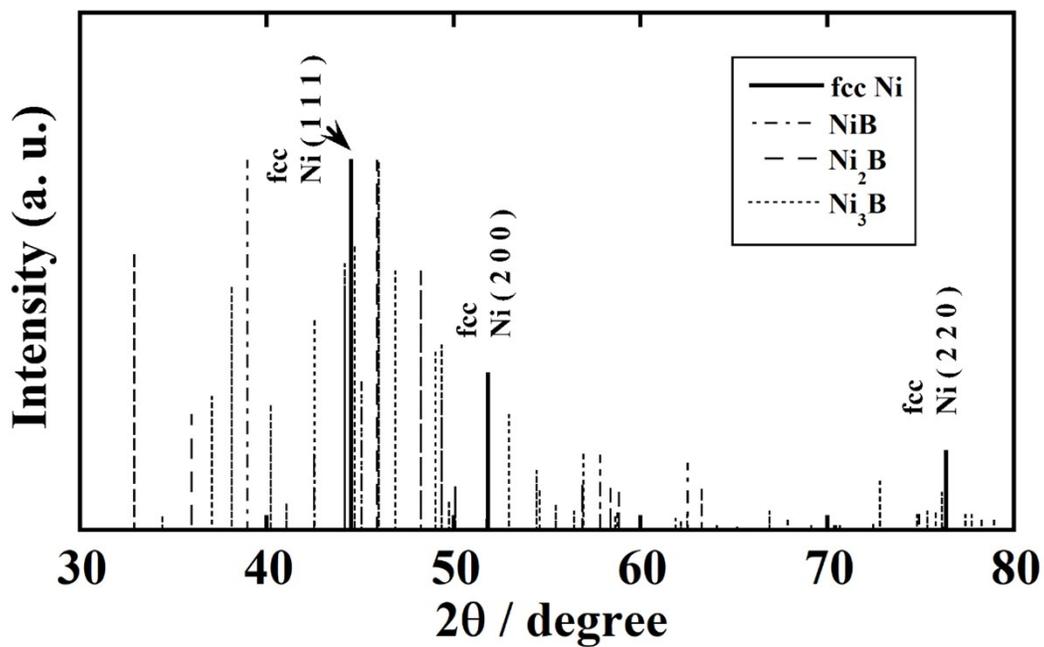


Figure S6. Comparison of X-ray diffraction patterns of fcc-Ni and Ni borides.