

Advanced Analysis Techniques for Oxide Cathodes

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Abstract

The advanced analysis techniques such as high resolution X-ray absorption spectroscopy (XAS), X-ray scattering, and photoelectron microscope (PEEM) using synchrotron radiation are probably able to open new opportunities for improving the performances of oxide cathodes with more clear and deep understanding.

1. Objectives and Background

The oxide cathode based on BaO is still an attractive electron source for the advanced cathode ray tubes (CRTs), since it was first introduced almost 70 years ago because of its lowest production costs and also its lowest work function.

In oxide cathode emission materials used for CRTs, the existence of free Ba on the surface is very important to produce the low work function surface of the oxide cathode. However, there are few experimental evidences about the free Ba formation on the surface, even though it is generally accepted in the literature¹. Moreover the formation mechanism of free Ba on the surface during activation is still less clarified. In this regards, we propose advanced analysis techniques for oxide cathode emission materials.

2. Results

X-ray absorption spectroscopy (XAS)

Compared with other surface sensitive techniques² such as Auger electron spectroscopy (AES), scanning low energy electron probe (SLEEP), X-ray photoelectron spectroscopy (XPS) or ion

scattering spectroscopy (ISS), one of the advantages of XAS is that the chemical information obtained is not only from the top surface layers, but also from the top several tens of nanometers in depth. The relatively large probing length makes XAS less vulnerable to the surface contamination than other surface sensitive spectroscopies. Our XAS measurements contribute to clear evidence of free Ba formation on the surface of oxide cathode emission materials.

In Figure 1(a), two X-ray absorption spectra are shown. The X-ray absorption spectra were measured on the Synchrotron Radiation Research Center's (SRRC) third generation ring. The bottom (open circles) and the upper (solid circles) curves are the Ba 3d spectra before and after activation from the binary oxide system on the Ni-W-Mg-Al base metal, respectively. Interestingly the Ba absorption significantly increased after activation. Since soft-X-ray absorption spectra are mostly from the top ~100 nanometers in depth, it is noteworthy that the large enhancement of the Ba content reaches to ~100 nanometers in depth from the surface during activation. Similar result was also obtained from the ternary oxide cathode. In Figure 1(b), the bottom (open circles) and the upper (solid circles) curves are the soft-X-ray absorption spectra before and after activation from the ternary oxide system on the Ni-W-Mg-Al base metal, respectively. Again the Ba content largely enhanced during activation. We note that the enhancement of the Ba content by activation is higher in the binary [Figure 1(a)] than in the ternary [Figure 1(b)] cathodes. This result is attributed to the surface area effect.

The XAS can exclude the surface contamination and the irregular geometry problems, resulting in providing more statistical and reliable data. So it has some prospect for better understanding of the relating reaction rate process of the oxide cathode emission materials. Finally our contribution is to show the experimental evidence on the free Ba formation on surface with more confidence.

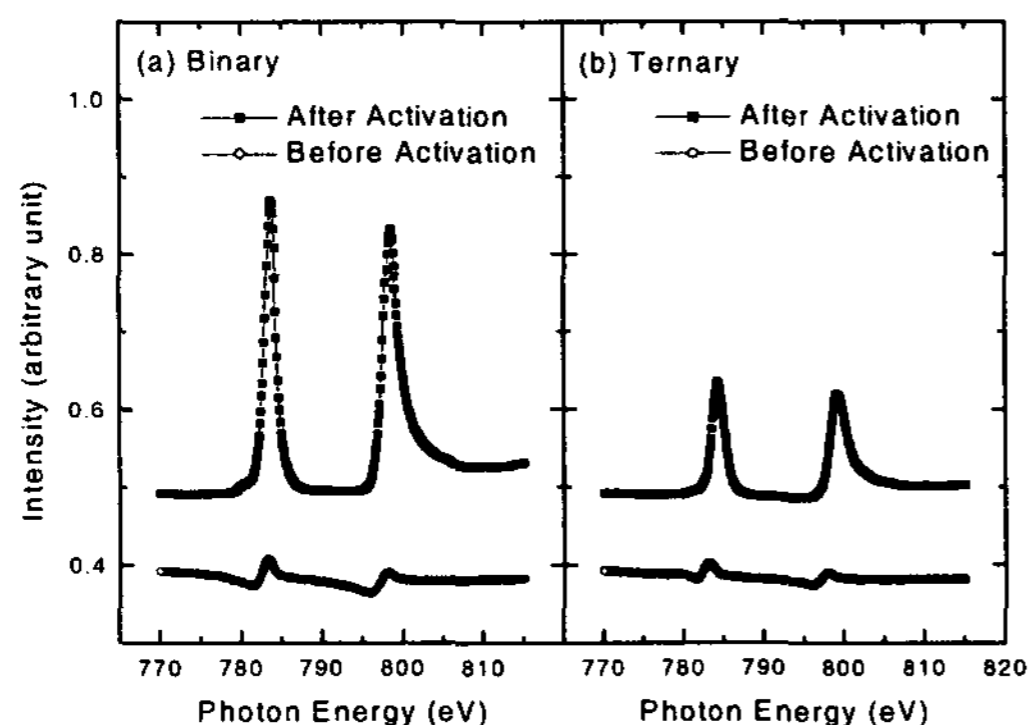


Figure 1. Ba 3d X-ray absorption spectra of oxide cathodes on the Ni-W-Mg-Al base metal. (a) binary system and (b) ternary system. The Ba content was significantly increased by activation.

High resolution X-ray scattering

Figure 2 shows the Ni(200) peaks of the base metal before and after activation, and after life test to 2000 h, measured using high resolution synchrotron X-ray scattering at Pohang Light Source. Interestingly, the peak shifts towards higher q value after activation, indicating that the Ni(002) lattice spacing relaxes to the bulk value. This result suggests that reducing elements (Mg, Si) moves out during activation and life probably to grain boundaries in Ni base metal.

The experimental evidence can contribute to giving more clear model for diffusion of reducing elements among grain boundaries in Ni base metal³.

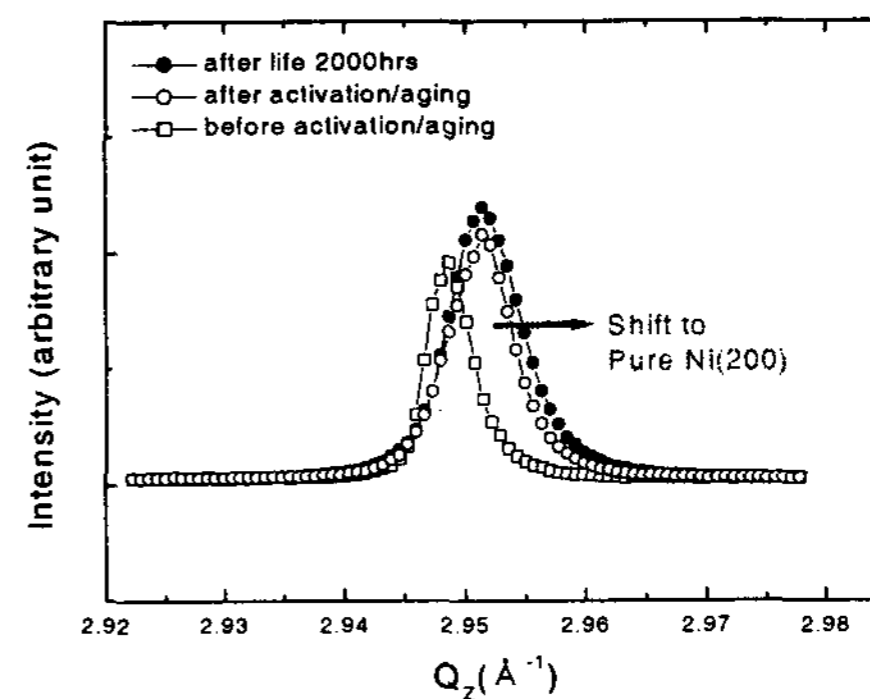


Figure 2. X-ray scattering profiles of Ni (200) peak of the Ni-Mg-Si base metal: before and after activation (0 hour), and after life test (2000 hours). The peak shifts towards that of pure Ni by activation.

3. Impact

One of the recent main subjects on the oxide cathode is to improve the robustness for longer life under higher emission loading⁴. In this regards, the understanding of free Ba formation and its dynamics is very important. For this purpose, the advanced new analysis techniques we tried here, including PEEM, enable to open new opportunities for improving the performances of oxide cathodes with more clear and deep understanding.

4. Acknowledgements

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5. References

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