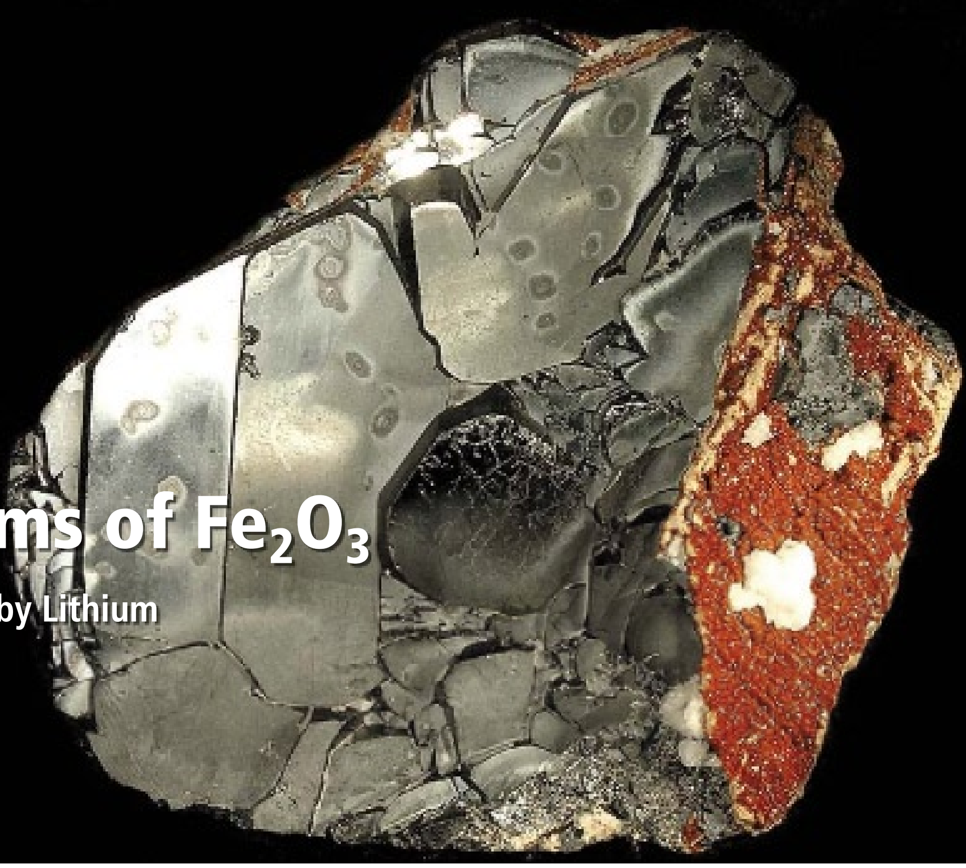


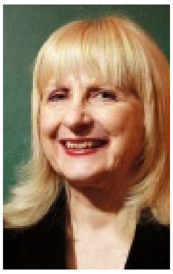
Nanosized Films of Fe_2O_3

Hematite Films Intercalated by Lithium

We have investigated nanosized thin films of α Fe_2O_3 (hematite) with addition of Li, by the impedance spectroscopy (IS), scanning electron microscopy (SEM), and X-ray diffraction (XRD). Combining all of these methods, the dependence of structural and electrical properties upon percentage of Li added into the matrix of these metal-oxide films was found.

Keywords

Nanosized Films of Fe_2O_3, Impedance Spectroscopy (IS), Scanning Electron Microscopy, X-ray Diffraction (XRD), Intercalation of Li



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Introduction

Thin-films containing nanosized grains of Fe_2O_3 are widely used in research into mainly magnetic and electronic devices [1]. Our intention is to construct charge-discharge Fe_2O_3-electrode battery with polymer electrolyte and to attach it to solar-cells [2]. Films of iron oxide derived by the chemical deposition method route were investigated by the impedance spectroscopy (IS), SEM, and XRD in order to establish the relation between electrical and the structural properties in nanostructured Fe_2O_3 and Fe_2O_3: Li (1% and 10%) films on glass substrate.

IS was applied to measure the resistance of nanostructured Fe_2O_3 films with different contents of lithium.

By SEM and XRD measurements, we have determined, besides the hematite nature of our samples, that they are composed of the nanosized crystalline grains in the size range from 10 nm to 200 nm. We have also found samples' steadiness during the eight-month period.

Experimental

The samples were nanostructured Fe_2O_3 films deposited on the glass substrates and were prepared using chemical vapor deposition procedure [3].

The grain size, the crystallinity, and the morphology were observed using scanning field emission electron microscopy (SEM, Zeiss, Supra 35VP). Figure 1 is showing SEM photograph Fe_2O_3: Li (1%), with magnification of 100.00 K. The identification and classification of prepared samples were made by the X-ray diffraction using a D4 Endeavor, Bruker AXS.

Results and Discussion

The primary goal of impedance spectroscopy measurements was to determine the electrical conductivity of the Fe_2O_3 films and then Fe_2O_3 films with different contents of Li. Measurements with Zn electrodes were performed in impedance and admittance modes. Figure 2 is showing an example of ac admittance data for the sample of Fe_2O_3 obtained at room temperature and equivalent circuits. Resistivities (R) obtained from admittance measurements at room temperature are shown in the second column of table 1.

Scanning field emission electron microscopy and XRD measurements were performed in order to check the grain size, the crystallinity, and the morphol-

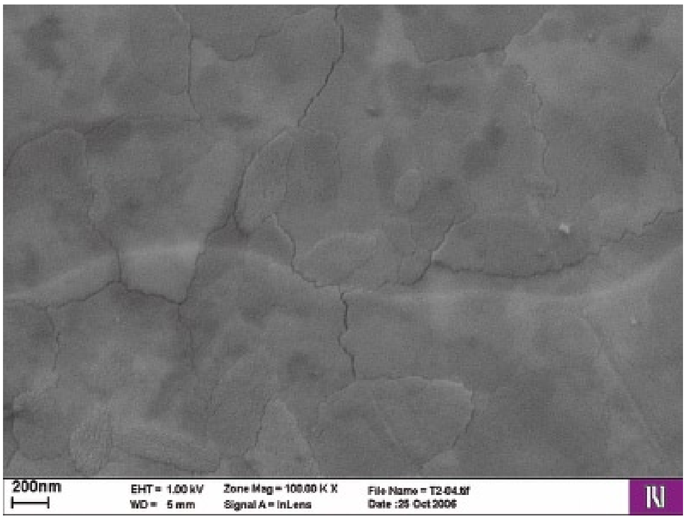

Fig. 1: SEM photograph Fe_2O_3: Li (1%), with magnification of 100.00 K.

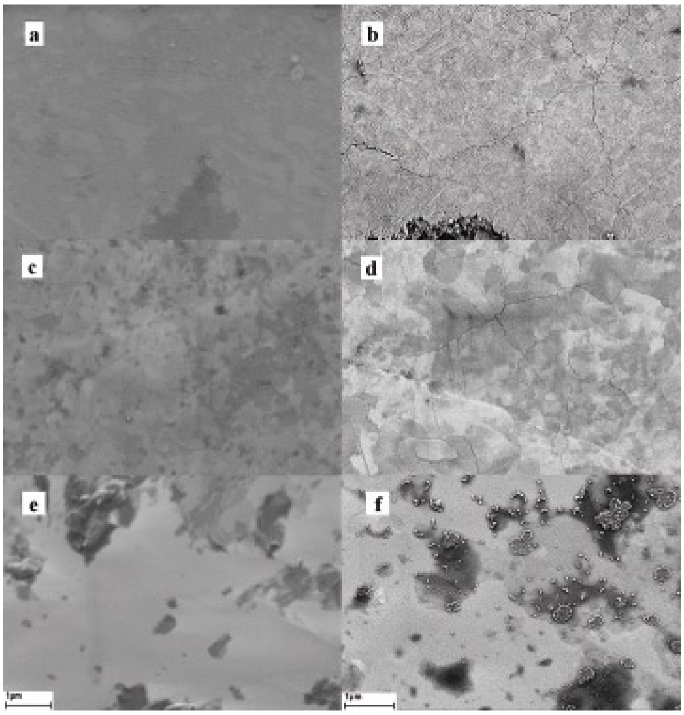

Fig. 3: SEM photographs Li free Fe_2O_3 (a), $Fe_2O_3$with 1% (c) and $Fe_2O_3$with 10% of Li (e), and the same films after 8 months (b), (d), and (f), respectively.

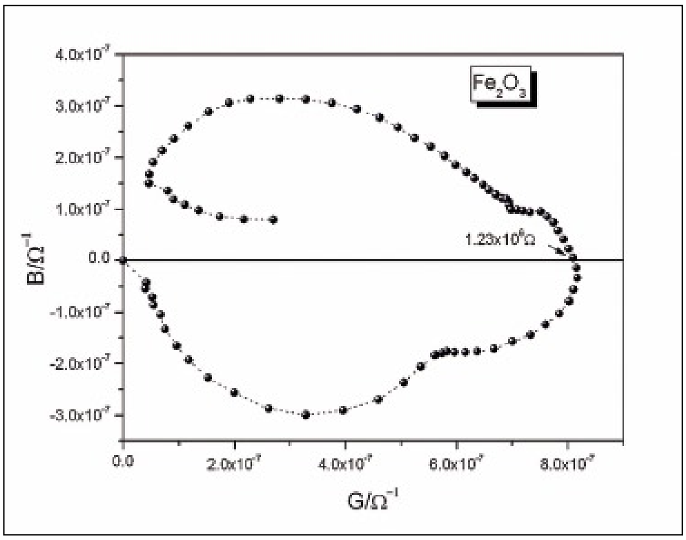

Fig. 2: (a) Admittance spectra Fe_2O_3 thin film measured at room temperature and (b) equivalent circuits and schematic admittance plot for Zn electrodes.

Sample	*T*/K	*R*/kΩcm	*n*/cm^{-1}[3]	*d*/nm[3]
Fe_2O_3	298	40	95	2.0
Fe_2O_3 with 1% Li	298	250	50	3.9
Fe_2O_3 with 10% Li	298	54	60	3.2

Table 1: Obtained parameters for different Fe_2O_3 samples: measurement temperature in degrees of *K*, resistivity *R* in kΩcm obtained by IS, low-frequency Raman modes *n* in cm^{-1}, and their respective nanosizes *d* in nm of Fe_2O_3 films on the glass substrate.

ogy, revealed by other methods [3].

SEM photographs of α-Fe_2O_3 and of the same material with added Li ions are shown on Figure 3. It is clearly visible on lower magnification that sample (a) shows much more homogeneous surface than the samples (c) and (e). The crystallinity is changed and films (c) and (e) became partly and completely amorphous, respectively. The surface of sample (e) shows good homogeneity and on higher magnification some nanoagglomerated grains are visible. Figures 3(b), 3(d), and 3(f) present SEM photographs of the same films after 8 months, demonstrating no significant difference upon earlier results.

The results of the XRD measurements showed the characteristic diffractogram of hematite structure (reference code 01-079-1741, mineral name: Hematite, synthetic, ICSD name: Iron Oxide). XRD clearly shows amorphization of the sample upon addition of Li+ ions [3].

Conclusion

As a conclusion, the present study showed that IS, SEM, and XRD could be applied for grain size and conductivity determination in nanosized films of Fe_2O_3 and Fe_2O_3: Li on glass substrate. This particular morphology is suitable for application in an advanced electrochemical cell concept, which could be used as charge storage for solar cells.

Acknowledgments

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