Feature-Ⅰ: Prediction and Measurement of Microstructures and Properties in Materials

Prediction and Measurement Technologies of Material Structure and Properties, the Technologies Supporting Kobelco Group's Material Development

The KOBELCO group manufactures and sells various metallic materials such as steel, aluminum, copper, welding materials, and titanium. In addition, the group continues to develop materials with characteristics superior to conventional ones in order to meet the expectations of the customers. New material development utilizes new analytical technologies, numerical calculation methods and forecasting technologies exploiting data science. This special feature introduces the latest technologies related to the "prediction and measurement of microstructure and properties," which support the products of the KOBELCO group and are used in the development of next-generation products.

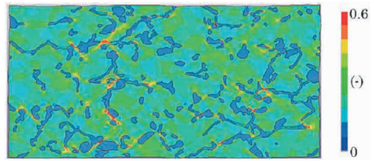


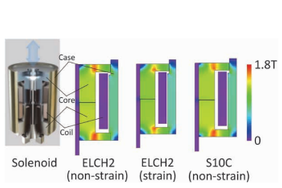
Fig.1 Distribution of equivalent plastic strain in DP steel (at 20% elongation)

Fig.1 shows the calculated micro-strain distribution in a DP steel deformed by 20%. In this technique, ferrite grains and martensite grains are identified from the SEM image, and multi-scale simulation based on the homogenized elasto-plastic theory considering the geometric shape and mechanical properties of both of the grains is performed. This technique offers an effective method that not only can reproduce the macroscopic stress-strain curve, but also simultaneously analyze the behavior of microscopic inhomogeneous deformation caused by the internal structure.

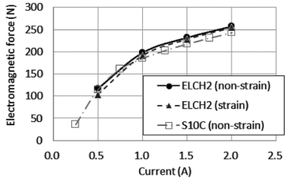
Feature-Ⅱ: Functional Materials and Solutions for Diverse Needs of Society

Various Functional Materials and Supporting Technologies in KOBELCO Group

Recently, remarkable progress has been made in electrification and ICT in the field of transport machinery, such as automobiles, and the demand for digital transformation (DX) is increasing in our daily lives as well. Such a trend also requires materials and parts with high/multi functionality. To meet this demand, KOBELCO group companies are creating high-value-added materials in the fields of electricity, electronics, and magnetism and providing them to society. In addition, with their advanced analysis and evaluation technologies the companies are striving to correctly evaluate the reliability and safety of products in these fields. This special issue introduces the latest functional materials and analysis and evaluation technologies, along with the processing technologies that support these materials from the KOBELCO group companies.



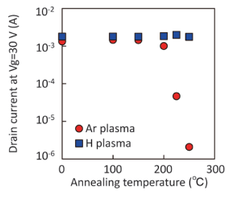
(a) Magnetic flux density distribution in solenoid components



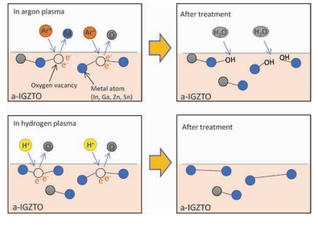
(b) Estimated magnetic force by FEM analysis

Fig.2 Electromagnetic characteristics of ELCH2 without annealing

Low-carbon steel S10C (Japanese Industrial Standards: JIS G 4015), which is widely used as a magnetic material, requires a costly heat treatment step called "magnetic annealing" to eliminate the lattice defects generated in the part fabrication process and to coarsen the crystal grains. Kobe Steel's ELCH2 is characterized by the fact that the same electromagnetic force can be obtained even when this "magnetic annealing" process is omitted, which has been verified by prototype solenoids. It has been analytically shown that, even if there is concentrated magnetic flux due to work strain, as shown in Fig.2(a), an equivalent magnetic force characteristic is obtained, as shown in Fig.2(b), and a rather high output is obtained under a great electric current.



(a) Annealing temperature dependence of drain currents



(b) Schematic representation of reducing electrical resistance by plasma processing

Fig.3 Effectiveness of hydrogen plasma treatment during source / drain fabrication process for a-IGZTO-TFT

The "IGZTO™" developed by Kobe Steel is a semiconductor material for the liquid crystal displays (LCDs) used in TVs, tablet PCs, notebook PCs, etc., that require high refresh rates. The effectiveness of hydrogen plasma treatment for the low resistance fabrication process of the source/drain region has been clarified for the top-gate-type thin-film transistor using this unique material (Fig. 3 (a)). The hydrogen plasma treatment has reduced the sheet resistance of the a-IGZTO film, and this low resistance state has exhibited no change after heat treatment, indicating a high thermal stability. The cause of this phenomenon is explained by a mechanism suppressing the replacement with each metal shown in Fig. 3 (b).

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