Nanostructured Electrochemical Reactro For NO_x Decomposition

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Dramatic improvements in the selective separation and purification of NOx in exhaust gases by an electrochemical reactor have been achieved. The novel electrochemical cells for NOx decomposition were developed by nano-scale control of penetrating pores and by distribution at the interfaces of ionic and electronically conducting grains through the electro-catalytic electrode of the cells (Fig.1). Electrochemical reduction reaction at the interface of NiO-YSZ grains resulted in a nanostructural development in the electrocatalytic electrode. NOx molecules were preferentially captured at the surface of Ni nano particles generated by reduction and re-crystallization of NiO grains. Nano-scale pores at the interfaces were generated by the volume reduction on the NiO-Ni transformation (Fig.2). Highly concentrated oxygen defects in YSZ grains located near the boundaries took an important role of oxygen ionization to remove it from NOx molecules. Nanostructural development of the electrocatalytic electrode layer was optimized effectively by control of applied voltage, current, temperature and initial grain size of NiO and YSZ.

The following reaction mechanism was proposed for NO decomposition on the nano-size Ni grains produced during the reactor operation.

$$NO + Ni \rightarrow Ni{-}NO$$
$$2Ni{-}NO \rightarrow 2NiO + N_2$$

NO gas molecules are chemisorbed on Ni and decomposes to form N_2, oxidizing Ni to NiO. NOx gas molecules introduced in nano-scale spaces have extremely high probability of interaction with Ni and oxygen vacancy in YSZ as a counterpart to receive oxygen molecules through this redox-reaction. The regeneration reaction of the reduction of NiO to Ni takes place at the NiO/YSZ interface under the reactor operation continuously.

$$NiO + V_O(ZrO_2) + 2e \rightarrow Ni + O^{2-}(YSZ)$$

Improvement in the current efficiency and suppression of the working voltage of the cells enabled their application as a novel reactor for NOx decomposition of gases from diesel engine vehicles and other industrial equipments with the advantage of less energy consumption in comparison with “the fuel penalty” for presently used catalytic systems (Fig.3). The obtained efficiency shown in the figure reached over twice of the level of a catalyst system.

The cells are able to work as a deNOx reactor even under excess oxygen contents up to 10% because of the selective separation to NOx molecules by the nano-space reaction. For the first time such nano-reaction has been shown to realize sufficiently applicable yielding rates.

[REFERENCES]

1. S.Bredikhin, K.Maeda and M.Awano, Journal of the Electrochemical Society **148,** (10), D133-D138, (2001).

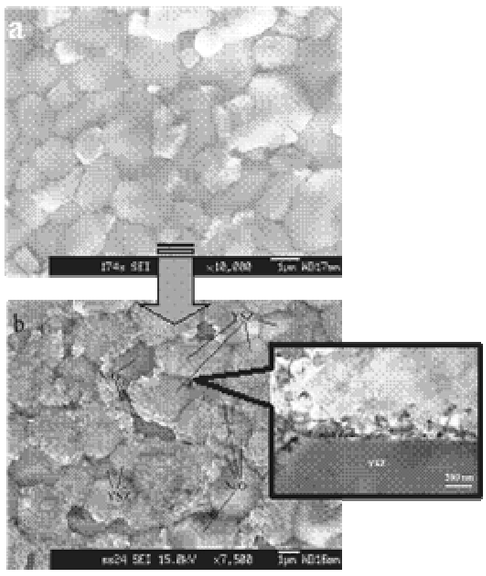

Figure 1: Microstructure of electrochemically treated electro-catalytic electrode

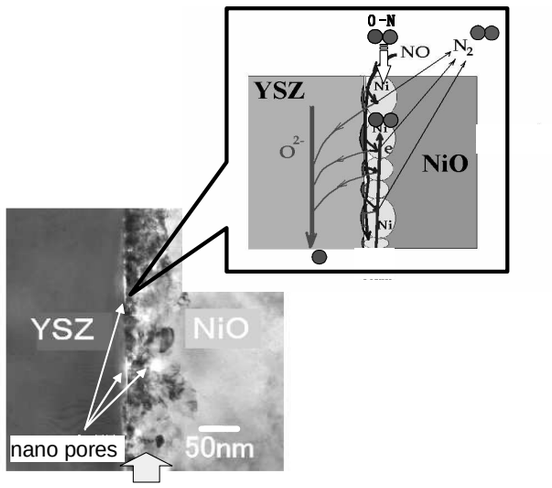

Figure 2: TEM image of NiO-YSZ interface and reaction model of selective NO decomposition.

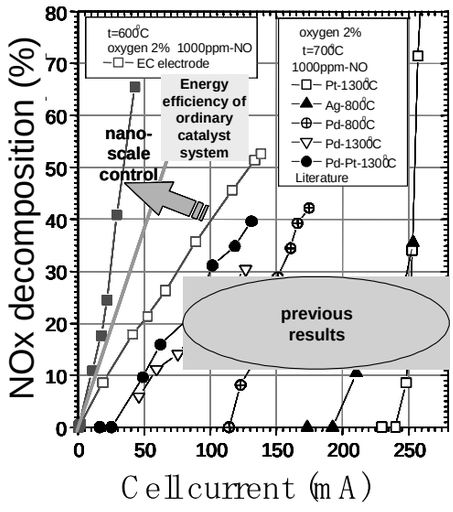

Figure 3: Improved de-NOx efficiency for applied current by nano- structurally controlled electrochemical cells.