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June 21, 2022

Japan Display Inc.
Idemitsu Kosan Co., Ltd.

Development of Poly-OS, a Poly-Crystalline Oxide Semiconductor Applicable to a Wide Variety of Displays

Japan Display Inc. ("JDI," Head Office: Minato-ku, Tokyo; Chairman and Chief Executive Officer: Scott Callon), and Idemitsu Kosan Co., Ltd. ("Idemitsu Kosan," Head Office: Chiyoda-ku, Tokyo; President and Chief Executive Officer: Shunichi Kito) have successfully co-developed an innovative poly-crystalline oxide semiconductor, Poly-OS, for use in a wide variety of displays, including wearable devices, smartphones, metaverse devices such as VR, Notebook PCs, and large-display TVs.

By integrating Idemitsu Kosan's newly developed proprietary poly-crystalline oxide[1] semiconductor material and JDI's proprietary backplane[2] technology, the new Poly-OS semiconductor contributes significantly to improving display performance by achieving both high mobility and low off-leak current[3] on Gen 6 mass production lines. Poly-OS can also be deployed to large-size Gen 8 lines and above, significantly reducing display manufacturing costs. Both JDI and Idemitsu Kosan are committed to actively promoting this innovative technology globally.

JDI has succeeded in developing the world's first practical application of Poly-OS on a Gen 6 mass production line at its Mobara Plant (Mobara City, Chiba Prefecture), using its proprietary backplane technology. JDI's HMO (High Mobility Oxide) Poly-OS implementation achieves 4X higher field-effect mobility than conventional OS-TFTs. JDI announced this HMO technology breakthrough on March 30, 2022. (JDI release: "JDI Develops World's First G6 Oxide Semiconductor TFT with 4X Improvement in Field-Effect Mobility – Breakthrough in Display Performance – ").

Idemitsu Kosan started the development of a poly-crystalline oxide semiconductor material IGO (Indium Gallium Oxide) for flat panel displays as part of its electronic materials business in 2006. IGO has high mobility equivalent to low temperature polysilicon (LTPS)[4], which could not be achieved with existing oxide semiconductors, along with stable thin-film transistor (TFT)[5] characteristics that can be applied to Gen 8 and larger substrate lines.

Both JDI and Idemitsu Kosan are supporting the ongoing development of Poly-OS technology so that it can be widely applied in diverse applications across the global display industry. JDI and Idemitsu Kosan are committed to contributing to a low-carbon society through display performance improvements, the evolution of the global display industry, and lower display power consumption.

About Poly-OS

Technology Overview

Like a-Si[6], conventional oxide semiconductor transistors can be easily manufactured on large areas and have low power consumption due to low off-leak current. However, their mobility is lower than that of LTPS, a high-performance technology mainly used in small- and medium-sized displays. The innovative Poly-OS semiconductor technology developed by JDI and Idemitsu Kosan significantly improves and resolves the challenges of conventional oxide's low field-effect mobility, while enabling higher performance equivalent to LTPS. Poly-OS thus makes it possible to create products that bring together the best features of existing backplane technologies (Fig. 1).

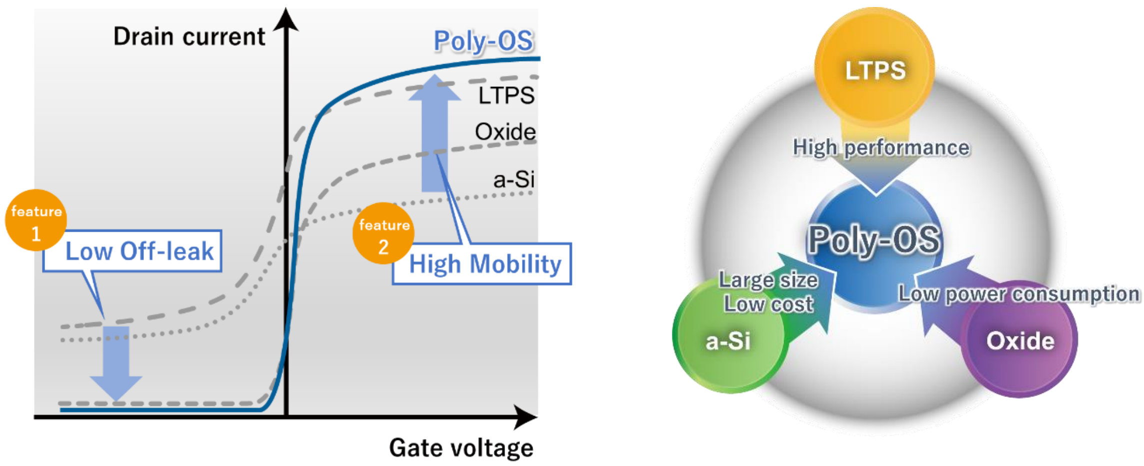

Fig. 1 Technology concept

Classification of Oxide Semiconductors

Oxide semiconductors with structures such as amorphous and C-axis aligned crystal/nano crystal[7] have been used in the active layer of transistors and thus are well-established and commercialized as mass production technologies. Idemitsu Kosan's proprietary IGO is characterized by its ability to generate a poly-crystalline state (Fig. 2) using the conventional process (450°C or lower) similar to existing amorphous oxide semiconductors. By using this poly-crystalline oxide semiconductor in the active layer, it is possible to maximize the inherent electron mobility of oxides.

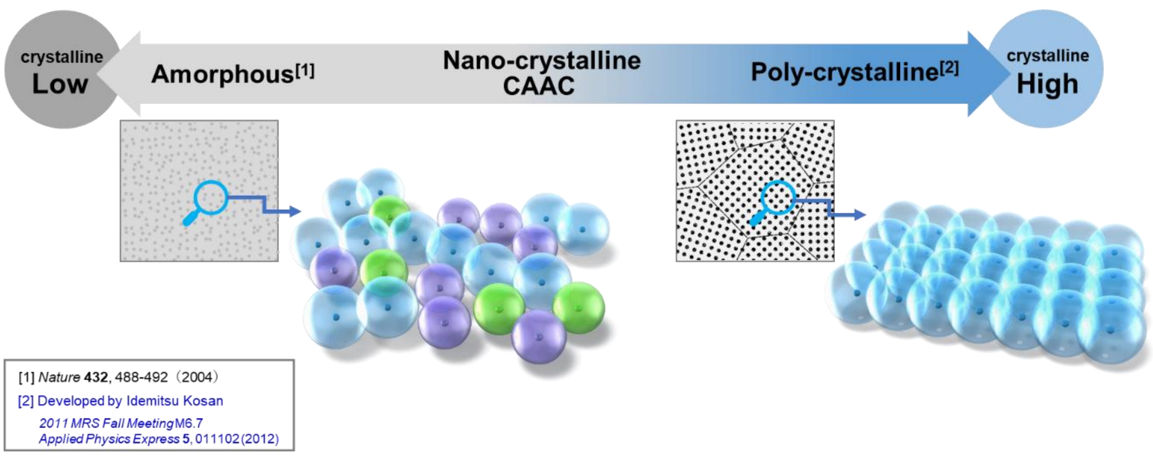

Fig. 2 Crystallinity of oxide semiconductors

Process Technology

Oxide materials with high electron mobility typically have difficulty controlling charge carriers and cannot be operated as transistors without modification. By integrating JDI's proven process know-how in CVD[8], sputter[9], annealing[10], and etching, Poly-OS makes possible stable operation with both high mobility and low off-leak current (Fig. 3 & 4). In addition, by adopting an optimal top-gate self-align structure[11] (Fig. 5) to increase on-current[12], stable characteristics that are independent of the channel width can be obtained even at 2 μm (the minimum channel length). The current driving capability is also equivalent to that of LTPS (Fig. 6).

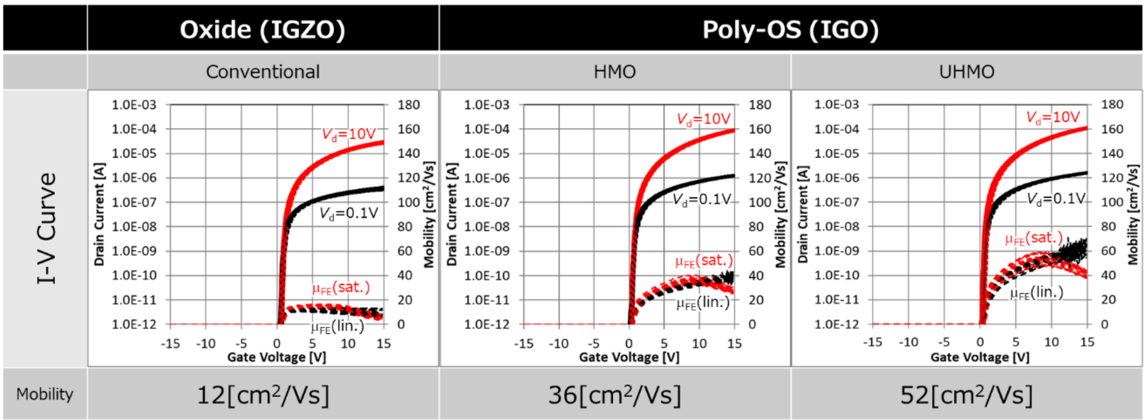

Fig. 3 Comparison of voltage-current characteristics of thin-film transistors with the same structure on a Gen 6 mass production line

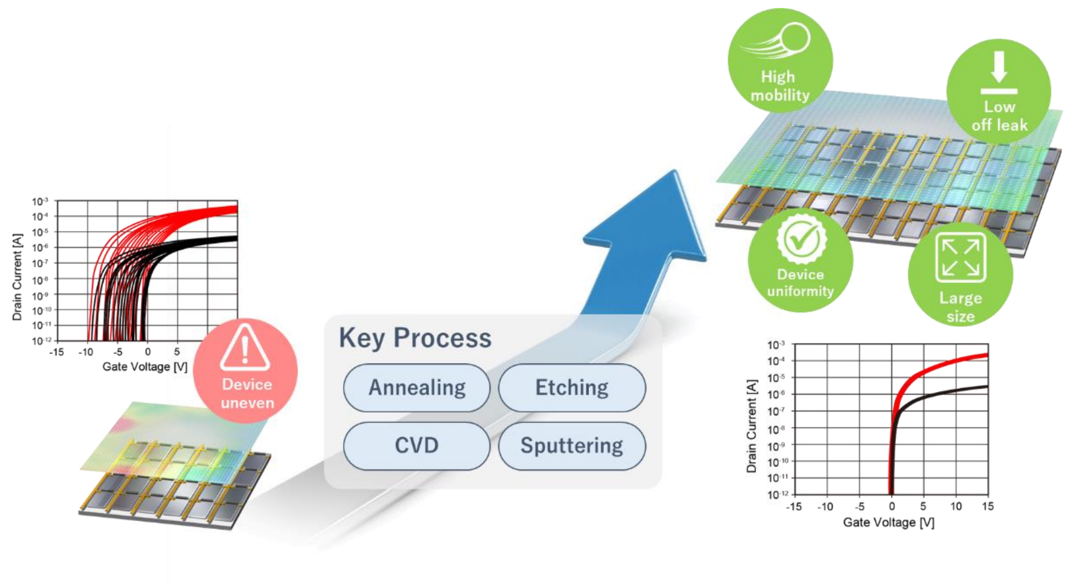

Fig. 4 Improvement of uniformity on a Gen 6 mother glass[13] (N=28pt)

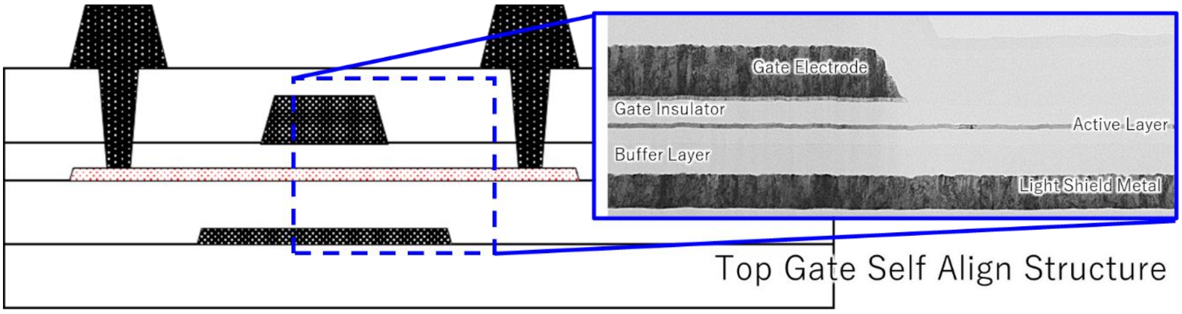

Fig. 5 Cross-sectional structure of a thin-film transistor

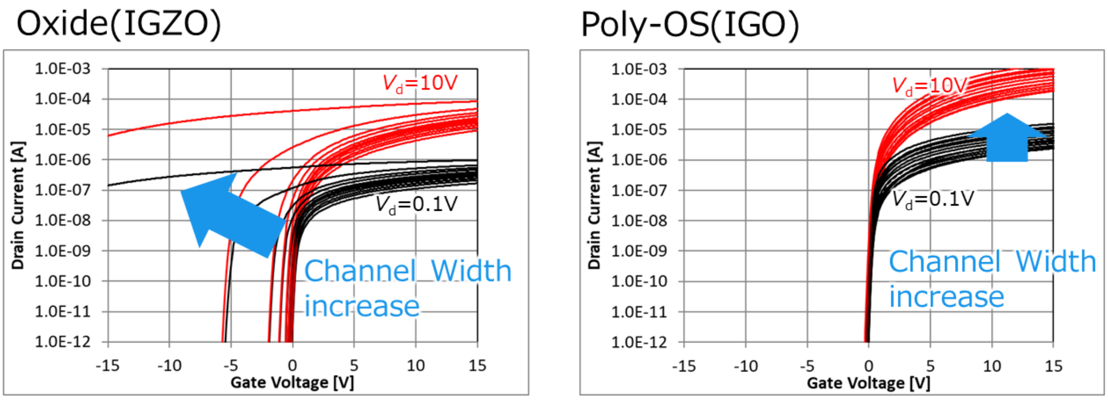

Fig. 6 Current increase when channel width in TFT is changed from 2 µm to 25 µm with a channel length of 2 µm

[1] Poly-crystalline oxide: A thin film in a poly-crystalline state composed of metal oxides.

[2] Backplane: A circuit substrate mounted with fine semiconductor devices that generates control signals and drives flat-panel displays.

[3] Off-leak current: Current that is not supposed to occur but leaks out when a transistor is turned off.

[4] Low temperature polysilicon (LTPS): Polycrystalline silicon formed using laser annealing at low temperature on a glass substrate. It has high electron mobility.

[5] Thin-film transistor (TFT): A transistor composed of thin films such as amorphous silicon, oxide, LTPS.

[6] a-Si (amorphous silicon): Silicon with non-crystalline structure used for thin-film transistors.

[7] C-axis aligned crystal/ nano crystal: Oxide semiconductor film which possesses a c-axis aligned crystal structure and microcrystals.

[8] CVD (chemical vapor deposition): Process to form a thin film on the substrate surface by chemical reaction.

[9] Sputtering: Process to form a thin film on the substrate surface by physical reaction with plasma.

[10] Annealing: Process to treat a thin film on a glass substrate by applying heat to improve the film quality.

[11] Top-gate self-align structure: TFT structure realizing high-speed operation with low parasitic capacitance.

[12] On-current: The current that flows when the transistor is turned on.

[13] Mother glass: Large-size glass used as a substrate in the manufacturing of flat-panel displays.

Company Profiles

Company Name	Japan Display Inc. (JDI)
Location	7-1, Nishi-shinbashi 3-chome, Minato-ku, Tokyo
Representative	Representative Executive Officer, Chairman, and Chief Executive Officer Scott Callon
Business Start	2012
Capital	100 million yen
Sales	295.9 billion yen

Company Name	Idemitsu Kosan Co., Ltd.
Location	2-1, Otemachi 1-chome, Chiyoda-ku, Tokyo
Representative	Representative Director, President, and Chief Executive Officer Shunichi Kito
Date Established	1940 (founded in 1911)
Capital	168.3 billion yen
Sales	6.7 trillion yen

Note: Capital and Sales are as of March 31, 2022.

~ Contact Information ~

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Idemitsu Kosan Public Relations Department Public Relations Section

https://www.idemitsu.com/jp/contact/newsrelease_flow/index.html