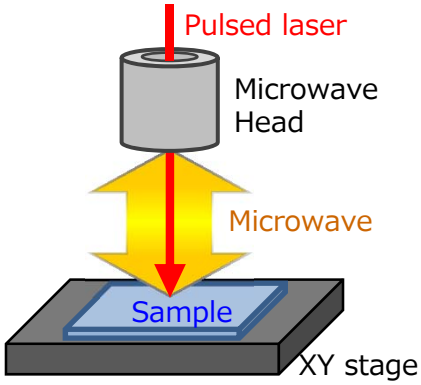
Analysis for lifetime of IGZO films by microwave photoconductivity decay (μ-PCD)

The carrier mobility and shift of threshold voltage are important parameters to control their electrical properties for TFT devices using oxide semiconductors, such as IGZO as channels, The results by microwave photoconductive decay (μ-PCD) are known to be related with those parameters.
The μ-PCD is an effective method to evaluate process conditions and uniformity of TFT devices.

1. Microwave photoconductivity decay (μ-PCD)

Carriers in sample are excited by the irradiation of pulsed laser. After that the excited carriers return to the initial states due to the recombination. The μ-PCD method can observe the transient of excited carriers, monitoring the microwave reflectivity.

✓ Schematic of μ-PCD

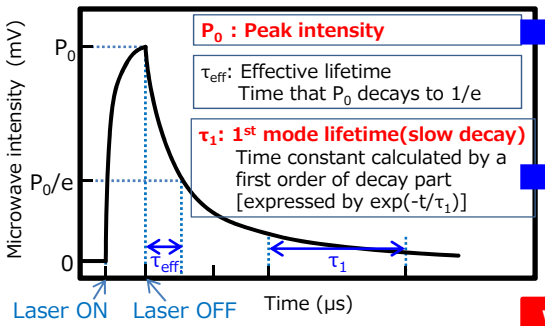


Spec of instruments
wavelength of laser: 349 nm
Mapping area: ～ 200 mm□

✓ Application to oxide semiconductor materials

- Non-contact and non destructive analysis.
- Microwave intensity mapping (Evaluation of uniformity).
- Relationship between the results and TFT characteristics.

✓ Schematic of result and general evaluation contents



TFT Mobility, μ (cm^2/Vs)
Mainly related with amount of defects in films.(tail states)
The higher P_0 indicates the higher TFT mobility.

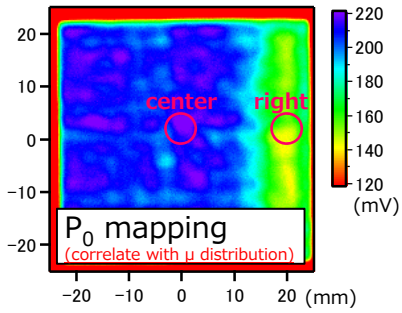
Shift of threshold voltage, ΔV_{th} (V)
Mainly related with amount of trap states in films.(~0.2eV)
The higher τ_1 indicates the higher ΔV_{th}.

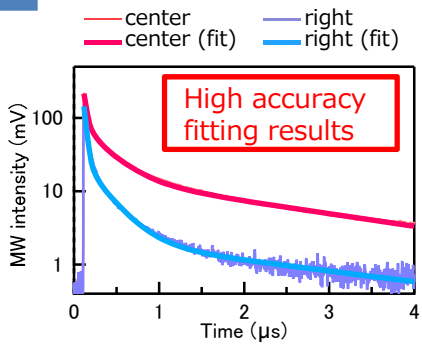
We analyze the decay curve in detail by multi components fitting model. ⇒ Extract τ_1 value more accurately.

2. Evaluation of IGZO films

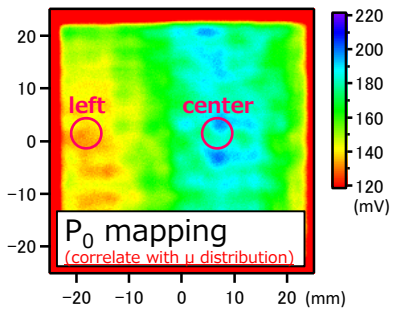
✓ **Samples**
Amorphous IGZO on Glass (50 mm□)
thickness: 1000 nm, In:Ga:Zn = 1:1:1
(*These samples are provided by Prof. Shigesato, Aoyama Gakuin Univ.)

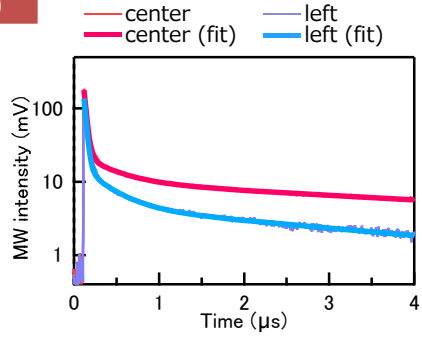
●IGZO film (O_2 flow rate 1 %)





●IGZO film (O_2 flow rate 2 %)





✓ Results

Sample		P_0	τ_1
O_2 rate 1 %	center	214 mW	2.5 μs
	right	151 mW	3.0 μs
O_2 rate 2 %	center	185 mW	6.8 μs
	left	141 mW	4.3 μs

P_0: O_2 2% < O_2 1 %
O_2 1 % plausibly exhibits higher carrier mobility than O_2 2 %.

τ_1 : O_2 1% < O_2 2 %
O_2 1 % is expected to show lower ΔV_{th} than O_2 2 %.

The application of μ-PCD to IGZO films before the fabrications of TFT devices yields us important information about the characteristics of these devices.

Toray Research Center, Inc.