Affiliation: Akio Suzuki, Professor, Production System Engineering Major, Graduate School of Engineering

1. Research topics

◎Research topics: Transparent Conductive Zine Oxide Film for Indium-free Solar Cells

◎Explanation of research topic (illustration on next page)

Indium tin oxide (ITO) has been playing an increasingly important role in the manufacture of display device electrodes, touch panels and solar cell electrodes for use in liquid crystal display(LCD) and organic light emitting display (OLED) as the market for these products continues to expand.

ITO is now an essential part of these electronic products. Rapidly growing demand for the rare indium metal that makes up ITO has resulted in dwindling reserves and roller coaster prices that has left the supply situation less than stable. In the face of what looks like an ever rising tide of demand for indium, researchers are racing against the clock to find alternatives before the supply runs out, One promising candidate is aluminum doped zinc oxide (Al-ZnO or AZO).

2. Featured publications (5)

1) A. Suzuki et al. : Surface-Flatness of Transparent Conducting An ZnO:Ga Thin Films Grown by Pulsed Laser Deposition ; Jpn. J. Appl. Phys., Vol. 35, NO.10(1996) pp. 5547-5461.

2) A. Suzuki et al. : Pulsed Laser Deposition of Transparent Conducting Indium Tin Oxide Films in Magnetic Field Perpendicular to plum ; Jpn. J. Appl. Phys., Vol.40(2001) pp. L401-L403.

3)A. Suzuki, T. Matsushita, T. Aoki et al. : Highly conducting transparent indium tin oxide films prepared by pulsed laser deposition ; Thin Solid Films, Volume 411(2002)pp. 23-27.

4) A. Suzuki et al. : Low Resistivity Transparent Conducting Aluminum Zinc Oxide Films Prepared by Pulsed Laser Deposition ;
Pulsed Laser Deposition of Transparent Conducting Indium Tin Oxide Films Prepared by pulsed laser deposition ; Thin Solid Films, Volume 445(2003)pp. 263-267.

5) A. Suzuki et al. : Ultrathin Al-doped transparent conducting zinc oxide films fabricated by pulsed laser deposition ; Tin Solid Films, Vol.517(2008)pp.1478-1481.

3. Corporate affiliates

Numerous, but unable to provide information due to confidentiality agreements signed

4. Other information (for reference)

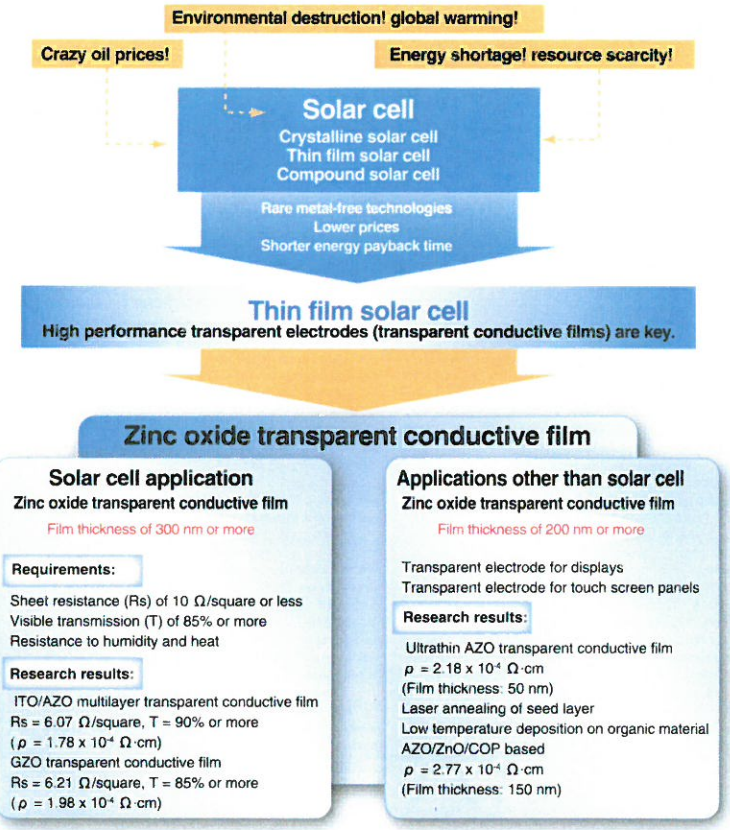
◎Main research field : Electron-device engineering and electronic materials

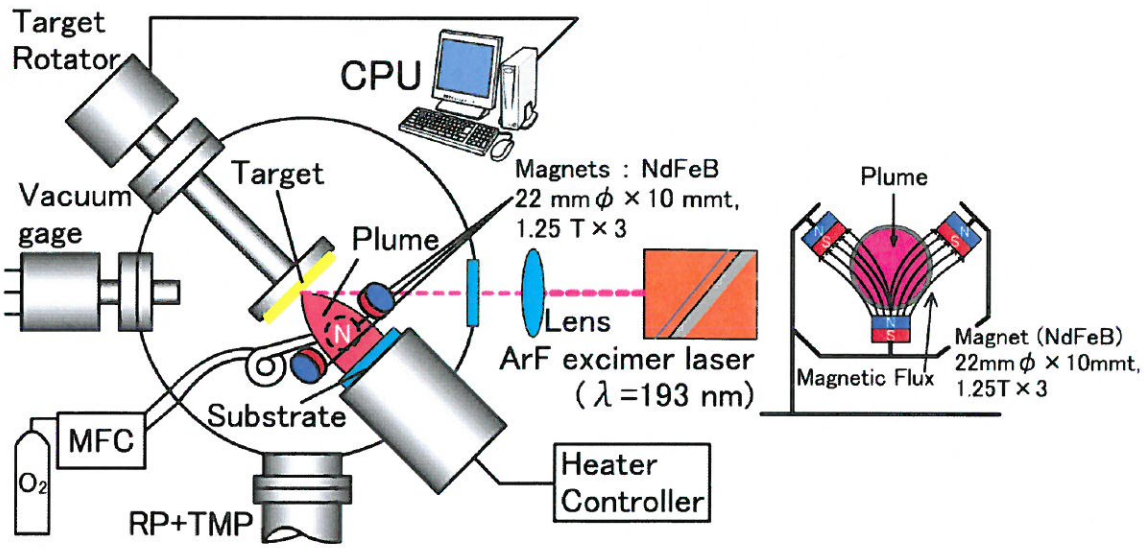
◎Other research : Made progress in optical recording films, Thin-films, Solar cells, High-Tc superconductors, Transparent conducting oxide (TCO) films (ITO, ZnO, p-type TCO), Environmental semiconductors, Fuel cells.

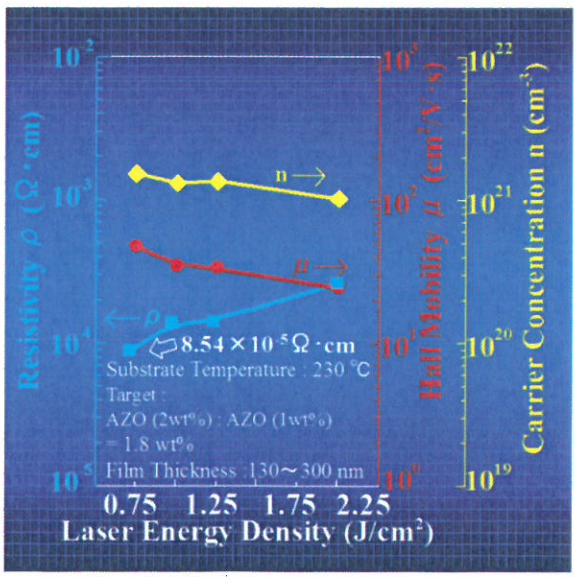
◎Academic society affiliations : Japanese Applied Physics, Electrical Engineering of Japan, Electronics, Information and Communication Engineering of Japan, Laser Engineering, and Vacuum Society etc.,.

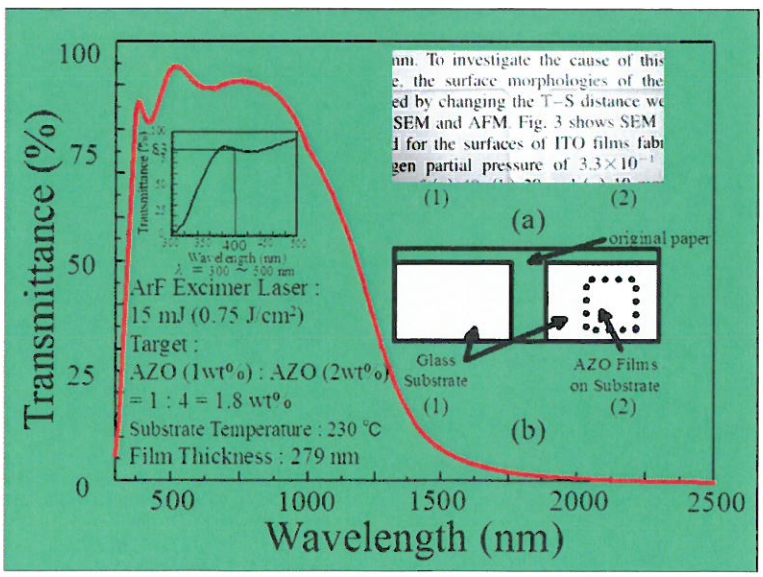
◎Awards record : Awarded many encouragement prizes related to the oral-cession from the attached institute and private foundations.

◎Publications authored : Wrote books of “The technology for free ITO in transparent conducting films with low resistivity and large area fabricated at low temperature“ etc.,.


Environmental destruction! global warming!
Crazy oil prices!
Energy shortage! resource scarcity!
Solar cell
Crystalline solar cell
Thin film solar cell
Compound solar cell
Rare metal-free technologies
Lower prices
Shorter energy payback time
Thin film solar cell
High performance transparent electrodes (transparent conductive films) are key.
Zinc oxide transparent conductive film
Solar cell application
Zinc oxide transparent conductive film
Film thickness of 300 nm or more
Requirements:
Sheet resistance (Rs) of 10 Ω/square or less
Visible transmission (T) of 85% or more
Resistance to humidity and heat
Research results:
ITO/AZO multilayer transparent conductive film
Rs = 6.07 Ω/square, T = 90% or more
(ρ = 1.78 x 10⁻⁴ Ω·cm)
GZO transparent conductive film
Rs = 6.21 Ω/square, T = 85% or more
(ρ = 1.98 x 10⁻⁴ Ω·cm)
Applications other than solar cell
Zinc oxide transparent conductive film
Film thickness of 200 nm or more
Transparent electrode for displays
Transparent electrode for touch screen panels
Research results:
Ultrathin AZO transparent conductive film
ρ = 2.18 x 10⁻⁴ Ω·cm
(Film thickness: 50 nm)
Laser annealing of seed layer
Low temperature deposition on organic material
AZO/ZnO/COP based
ρ = 2.77 x 10⁻⁴ Ω·cm
(Film thickness: 150 nm)


Target Rotator
CPU
Target
Vacuum gage
Plume
Magnets : NdFeB
22 mmϕ × 10 mmt,
1.25 T × 3
Lens
ArF excimer laser
(λ =193 nm)
Substrate
MFC
O2
RP+TMP
Heater Controller
Plume
Magnet (NdFeB)
22mmϕ × 10mmt,
1.25T × 3
Magnetic Flux


Resistivity ρ (Ω·cm)
Hall Mobility μ (cm²/V·s)
Carrier Concentration n (cm⁻³)
n
μ
ρ
8.54×10⁻⁵Ω·cm
Substrate Temperature : 230 ℃
Target :
AZO (2wt%) : AZO (1wt%)
= 1:8 wt%
Film Thickness : 130~300 nm
0.75 1.25 1.75 2.25
Laser Energy Density (J/cm²)


Transmittance (%)
Wavelength (nm)
ArF Excimer Laser :
15 mJ (0.75 J/cm²)
Target :
AZO (1wt%) : AZO (2wt%)
= 1 : 4 = 1.8 wt%
Substrate Temperature : 230 ℃
Film Thickness : 279 nm
(a)
(1)
(2)
original paper
Glass Substrate
AZO Films on Substrate
(b)