

**Laboratory of Prof. Chunlei Wang,
Florida International University,
April 20, 2023**

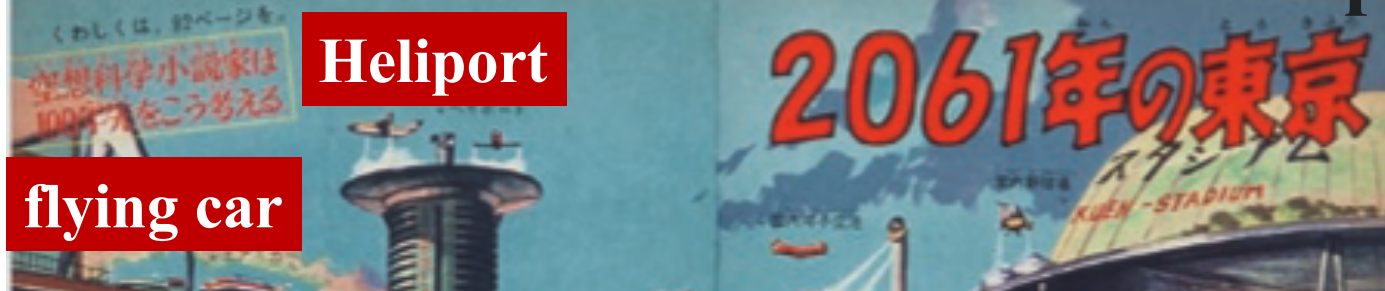
A New Look at Oxides

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retrofuturism: the future as seen from the past



Heliport

flying car

**The future, of course, does not exist
except as
an act of belief or imagination.**



Spandex?

flying car

street TV device

<https://www.hiptoro.com/p/30-predictions-from-retro-future-that-were-either-a-hit-or-a-miss/>

Magazine for 4th grade (9-10 old) of elementary school (Jan., 1961)

Our R&D

- **Oxides (ZnO, In₂O₃) as a next-generation material**
 - **Conductivity control (*n*- or *p*-type) by doping**
 - **Thin film manufacturing equipment that enables low-temperature, high-speed, large-area deposition**
 - **Ultra-thin (<10 nm) oxide thin films for mechanical property control**
 - **high carrier transport**

A New Look at Oxides

Electronics
high breakdown voltages
power electronics

- HEMTs
- FETs

Optoelectronics

- LEDs (DUV, VUV)

Transparent conductors
used as electrodes for

- LEDs, LCD TV
- Solar cells
- Smart windows

Transparent EMI shielding
material

Nanotechnology, *pn* junction, Tailor and control of functional impurity, defects, surface & interface

Radiation resistant materials,
Space industry

The materials used plays a large
role: the useful lifetime of the
satellite, robot, or
the lunar base.

**Biological and
medical applications**

- new antibacterial
agents for health care

For wide applications, to develop a low-temperature process with Solid Phase Crystallization

Firstly, *n*-type doped **amorphous (*a*-)** In₂O₃ films deposited on glass substrates at room temperature.

Then, the ***a*-films** are annealed at temperatures ranging from 150 to 300 °C for 30 min in air or under vacuum condition, to achieve high Hall mobility **transparent conductive polycrystalline** In₂O₃ films.

Ce-doped In₂O₃:

E. Kobayashi, Y. Watabe, T. Yamamoto, APEX, 8 (2015) 015505.

E. Kobayashi, Y. Watabe, T. Yamamoto, Y. Yamada, Sol. Energy Mater., Sol. Cells, 149 (2016) 75. cells: **commercially solar cells**

W-doped In₂O₃:

Y. Furubayashi, M. Maehara, T. Yamamoto, J. Physics D, 37 (2020) 375103.

Y. Furubayashi, S. Kobayashi, M. Maehara, K. Ishikawa, K. Inaba, T. Sakemi, H. Kitami, T. Yamamoto, APEX, 13 (2020) 065502.

Develop your own idea

idea: interaction between fundamental and applied science and interface between many different materials, such as interaction between fundamental science and applied science, and interface between different kinds of materials such as metal/metal, metal/semiconductor, semiconductor/semiconductor, metal/insulator, and insulator/insulator



**Scientific observation
with modeling**

**Definite need
New and expansive concept**