Technology Offer

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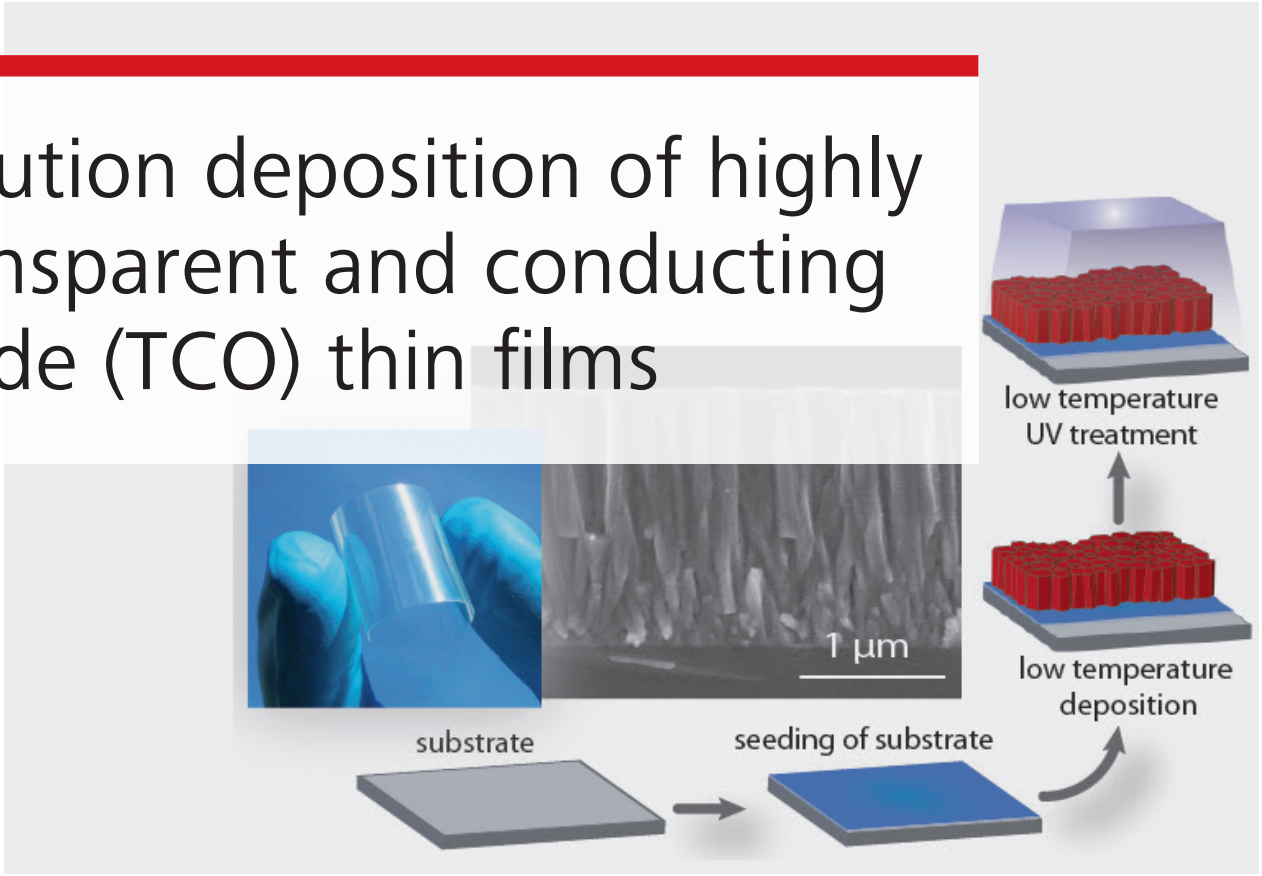
Empa
Materials Science and Technology

# Solution deposition of highly transparent and conducting oxide (TCO) thin films




## Invention

**A simple, non-vacuum, low-cost, eco-friendly and easily up-scalable aqueous chemical deposition method for aluminum doped zinc oxide (AZO) transparent conductive thin films is presented. The new deposition process requires only minimum equipment and instrumental investments.**

## Background

Indium tin oxide (ITO) is currently widely used as transparent conductive electrode material. This material relies on a limited abundance of the element indium. For a cost reduction of products and sustainable growth of their use, earth abundant and inexpensive alternative TCOs are necessary – a fact also reflected in a predicted non-ITO transparend conductive oxides (TCO) market of almost 1 billion in 2016 [1]. To fully exploit the potential of alternative TCOs non-vacuum deposition techniques are essential to avoid the large equipment cost and low material utilization of commonly employed vacuum deposition methods. However, the solution deposition of TCOs faces major drawbacks such as [2]:

– time consuming high temperature annealing,
– use of toxic and/or reactive chemicals, and
– necessity of conductive substrates.

Up to now these factors prohibited an ecologic and economic efficient fabrication of TCOs. In contrast, we present a novel process with simple equipment for low cost deposition of TCOs which is applicable on any substrate – rigid or flexible.

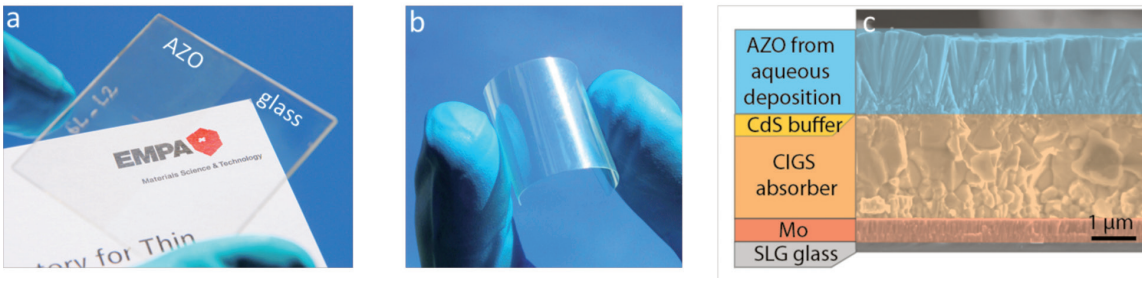
## Advantages

With the new process AZO thin films are grown by aqueous chemical bath deposition overcoming all above stated drawbacks:

– the process is economically favorable being independent from any vacuum deposition steps resulting in low equipment investment costs,
– the process is easily up-scalable,
– the process relies on "off-the-shelf", easy available, low cost chemicals, and
– the process is environmental friendly and does not use any toxic/reactive chemicals and produces no toxic waste.

## Applications

rigid | flexible | opto-electronics




The aqueous solution deposition of transparent (> 90% transparency in visible light) and conductive ($5 \times 10^{-3}$ Ωcm) AZO films can be applied to diverse optical and opto-electronical applications such as e.g.:

– rigid substrates with excellent transmission comparable to glass
– flexible, temperature sensitive polymer substrates as demonstrated here for PET foils
– any opto-electronic devices (thin film transistors, display technology) or as window layer for solar cells of different kind – demonstrated here for a Copper Indium Galium diselenide (CIGS) solar cell
– Further possible applications are found in the field of piezoelectrics, gas sensors or even as meta-materials, as recently reported [3].

## Ownership

Empa, Swiss Federal Laboratories for Materials Testing and Research, Ueberlandstrasse 129, CH-8600 Duebendorf; *Patent pending*

## References


[1] NanoMarkets, Report# Nano-425, Emerging markets for non-ITO transparent conductive oxides Market study TCOs, 2011, published September 26.
[2] A. Hardy, M.K. Van Bael, *Nat. Mater.,* **2011**, *10*, 340
[3] G.V. Naik et al, *PNAS,* **2012**, *109,* 23
[4] H. Hagendorfer et al., *Adv. Mater.,* **2013**, DOI: 10.1002/adma.201303186


## Keywords

Transparent conductive oxides, non-vacuum deposition, aqueous solution deposition, chemical bath deposition, low temperature process, flexible substrates, opto-electronics, RF-shielding, antistatics, smart-windows.

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