Recipes for Innovasteel4CIGS:

# Al2O3

## Recipe 1

0.02 M of Aluminium isopropoxide Al(OPri)3 was dissolved in 50 mL of 2-ethoxyethanol and stirred for 30 min. Then, acetylacetone (AcAc) was added and stirred for another 30 min. At last, a small amount of (10 mL) glacial acetic acid was added to the mixture solution and then stirred for 2 h to obtain the clear and transparent pale-yellow solution. The molar ratio of AcActo Al(OPri)3 was 1:1. The whole synthesis process was performed at 105°C in a saline water-bath.

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| **Chemicals** | Aluminium isopropoxide, 2-ethoxyethanol, acetylacetone, glacial acetic acid |
| **Processing steps after deposition** | Prepared layer dry at 200°C for 10 min just after coating and then pyrolyzed at 400°C for 10 min. Finally, the samples were calcined at 500°C for 3h at a heating rate of 5°C /min in a muffle furnace to form the Al2O3 films. |
| **Air/N2** | Air |
| **Toxicity** | 2-ethoxyethanol is toxic |
| **Deposition Technique in the Paper** | Spin coating |
| **Substrate in the Paper** | Platinum |

## Recipe 2

The reagents were aluminium isopropoxide (IPA), deionized water (H2O), and nitric acid (HNO3). The IPA:H2O:HNO3 molar ratio used was 1:60:0.10. The deionized water was heated at 85°C; reaching this temperature the nitric acid was inserted; and then, the aluminium precursor (powder compound) was added slowly. The solution was heated at 90°C for 24 h.

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| **Chemicals** | Aluminium isopropoxide, nitric acid |
| **Processing steps after deposition** | Each layer had been dried at 100°C for 15 min between each deposition step and finally, the tools were heat-treated at 450°C for 1 h to favor the densification of the sol-gel films. |
| **Air/N2** | Air |
| **Deposition Technique in the Paper** | Dip-coating with a withdrawal speed of ~0.4 mm/s |
| **Substrate in the Paper** | - |

## Recipe 3

Mix 27.71 g aluminum sec-butoxide, 11.26 g acetylacetone, 300 mL isopropanol together

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| **Chemicals** | Aluminium sec-butoxide, acetylacetone, isoproponal |
| **Processing steps after deposition** | the films were pre-annealed at 200°C for 5 min and then annealed again for 5 min at  350°C in an oven |
| **Air/N2** | Air |
| **Deposition Technique in the Paper** | Slot-die coating |
| **Substrate in the Paper** | Stainless steel Foil |

# SiO2

## Recipe 1

Silica sols were prepared starting from tetraethyl orthosilicate (Si(OC2H5)4, TEOS), 2-propanol (2-C3H7OH), 2-butanol (2-C4H9OH), water, and HNO3 with molar ratios of TEOS:H2O:2- C3H7OH:2-C4H9OH:HNO3 = 1:6:7:4:5 × 10-3 . TEOS was reacted with a mixture of the required amount of water, 2-propanol, and nitric acid. After 2 h of reaction, 2-butanol was added, and the sol was further stirred for 1 h.

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| **Chemicals** | tetraethyl orthosilicate, 2-propanol, 2-butanol, nitric acid |
| **Processing steps after deposition** | Films were dried for 10 min at 80°C in air. Then anneal the films for 1 h at 500°C in air to eliminate the residual organics. |
| **Air/N2** | Air |
| **Deposition Technique in the Paper** | Spin coating |
| **Substrate in the Paper** | fused silica or glass substrates |

# ZrO2

## Recipe 1

The preparation process for ZrO2 sol. The starting chemicals were zirconium n-propoxide (Zr(OC3H7)4, 70 wt% solution in 1-propanol), 1-propanol (C3H7OH), 2-propanol, acacH, and water with the following molar ratios: Zr(OC3H7)4:C3H7OH: 2-C3H7OH:H2O:acacH = 1:8:3:4:1. The usual procedure was applied. The Zr precursor was first chelated with acacH dissolved in 1-butanol or THF and the resulting solution was stirred for 1 h. Then the required amount of water dissolved in 2-propanol was added for hydrolyzing the Zr precursor and the sol was stirred for 1 h before adding the metal-containing solution. The resulting sol was further stirred for 1 h.

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| **Chemicals** | zirconium n-propoxide, 1-propanol, 2-propanol, Acetylacetone |
| **Processing steps after deposition** | Films were dried for 10 min at 80°C in air. Then anneal the films for 1 h at 500°C in air to eliminate the residual organics. |
| **Air/N2** | Air |
| **Deposition Technique in the Paper** | Spin coating |
| **Substrate in the Paper** | fused silica or glass substrates |

## Recipe 2

For sol-gel solution, zirconium (IV) butoxide, ethanol, acetylacetone, and distilled water were prepared at fixed molar ratio of: 1.25:20:1:3.2. Zirconium (IV) butoxide is a precursor, ethanol act as solvent, acetylacetone act as chelating agent, and distilled water for hydrolysis. First, zirconium (IV) butoxide and ethanol were mixed and stirred at room temperature using magnetic stirrer for 30 minutes. Then acetylacetone was added to the mixture continued to stir for another 30 minutes. Distilled water then added to continue the for another 30 minutes.

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| **Chemicals** | zirconium (IV) butoxide, ethanol, acetylacetone, and distilled |
| **Processing steps after deposition** | Samples then annealed at 350°C for two hours |
| **Air/N2** | Air |
| **Deposition Technique in the Paper** | Dip coating |
| **Substrate in the Paper** | Mild Steel |