Sundew Technologies

DATASHEET

ALD-CAP®

Exceptional Barrier Performance

ALD-Cap® is a flexible ceramic coating with exceptional barrier performance due to the pin-hole free and low stress nature of the atomic layer deposition (ALD) films used. ALD lays down films one atomic layer at a time. The films are inherently uniform, pin-hole free and virtually 100% conformal to the substrate surface. The physical properties of ALD- Cap® are summarized in the table below.

The extremely low permeability levels allow for efficient protection of environmentally sensitive devices such as organic light emitting diodes (OLED) and solar photovoltaics. For comparison, water vapor transmission rates (WVTR) for OLED must be < 10^{-6} g/m^2/day, and oxygen transmission rates (OTR) must be < 10^{-3} cm^3/m^2/day. For Organic Photovoltaics, the required WVTR is at the high level of 10^{-5} g/m^2/day. These transmission rates are several orders of magnitude smaller than what is possible using any polymer based coatings as the table indicates. Sundew has partnered with leading suppliers for OLED and solar barrier films to use ALD-Cap® as a barrier for these applications.

Property	ALD-Cap	Parylene C	Urethane
Hardness (GPa)	8-10	0.13	<<0.13
Young's Modulus (GPa)	130-180	2.8-3.2	1.5
Elongation to Failure (%)	100-300	200	250
Density g/cm^3	3-5	1.29	0.9-1.2
Index of Refraction	1.55-1.75	1.639	1.5-1.6
Dielectric Constant (DC)	6-9	3.15	3.5
Dielectric strength (MV/cm)	>8	2.2-2.8	1.4
Oxygen permeability, atm (cm^3 •mm/m^2•day)	< $1\text{x}10^{-7}$	2.83	80
Water Vapor permeability, 38°C (g•mm/m^2•day)	< $4\text{x}10^{-10}$	0.083	0.7
Maximum Temperature (°C)	>1500	290	130
Linear Coeffient of Expansion (10^{-6}/°C)	6	35	100-200
Heat dissipation (W/cm^2 C, at 0.2 µm)	2550	0.33	<0.16
Typical thickness (µm)	0.05-0.2	25	25-75

The Premier Environmental Protection Coating

ALD-Cap® provides exceptional performance for many applications requiring the highest level of environmental protection. For example, high reliability electronic components coated with ALD-Cap® demonstrated hermetic performance that passes MIL-STD 883E environmental endurance testing with total thickness as low as 200 nm. This allowed use for the first time of non-hermetic off-the-shelf packaging in electronic systems deployed in radar systems for Navy ships.

As a versatile, non-invasive add-on, ALD-Cap® can be used at different stages of the IC or electronic assembly. It can be applied at the wafer-level, replacing SiN-cap passivation, as well as at the die or the package level. If needed, ALD-Cap can also be implemented in combination with thicker conformal films for added ruggedness. The atomic level control of film composition offered by the ALD technique allows for tailoring specific adhesion layers to different substrates. This yields consistent high adhesion to various materials with adhesion often comparable to the adhesion strength of galvanized zinc to steel, as shown in the table below.

Substrate	Application	Coating Adhesion Pull Strength (PSI)
Immersion tin	PCB finish	1,700
Bright electroplated tin	PCB finish	>1,500
Gold	PCB and package finish	>1,400
Copper	Many	>1,600
Monel	Pressure sensors	>2,000
PET (FOLED Grade)	FOLED substrate	>1,200
PEN (FOLED Grade)	FOLED substrate	>1,250
Lexan	Many	>1,400
Kapton	Many	1,000
FR4	PCB material	>2,500
R/Flex	PCB material	1,200
Thermosetting epoxy	PEM package material	>2,500
3M scotch-weld 2216 B/A	IC attachement	>3,300
17-4 stainless steel	Medical surgical tools	1,750
Titanium	Medical implants	1,500
Glass	Many	>2,000

Nanolamination for Optimal Performance

The typical structure of ALD-Cap® is a nanolamination of Al_2O_3/TiO_2 layers capped with a TiAlO composite corrosion protection layer, as the SEM cross-section below shows. Many other alternative combinations can be used such as Al_2O_3, Al_2O_3/TiO_2 lamination, Al_2O_3/SiO_2 lamination, Al_2O_3/ZnO. Corrosion protective alternatives have been SiO_2, BN and AlBNO. Actual composition and layout is determined based on performance.

Our ALD-Cap® process allows for easy optimization of film recipes with excellent repeatability and with no need to re-optimize the process. For example, any desired combinations of Al_2O_3/TiO_2 lamination can be written into a recipe and executed to perfection once the parameters of the Al_2O_3 and TiO_2 processes are defined. If adhesion promotion is needed, a thin interface layer of 1-2 nm of other materials can be added.

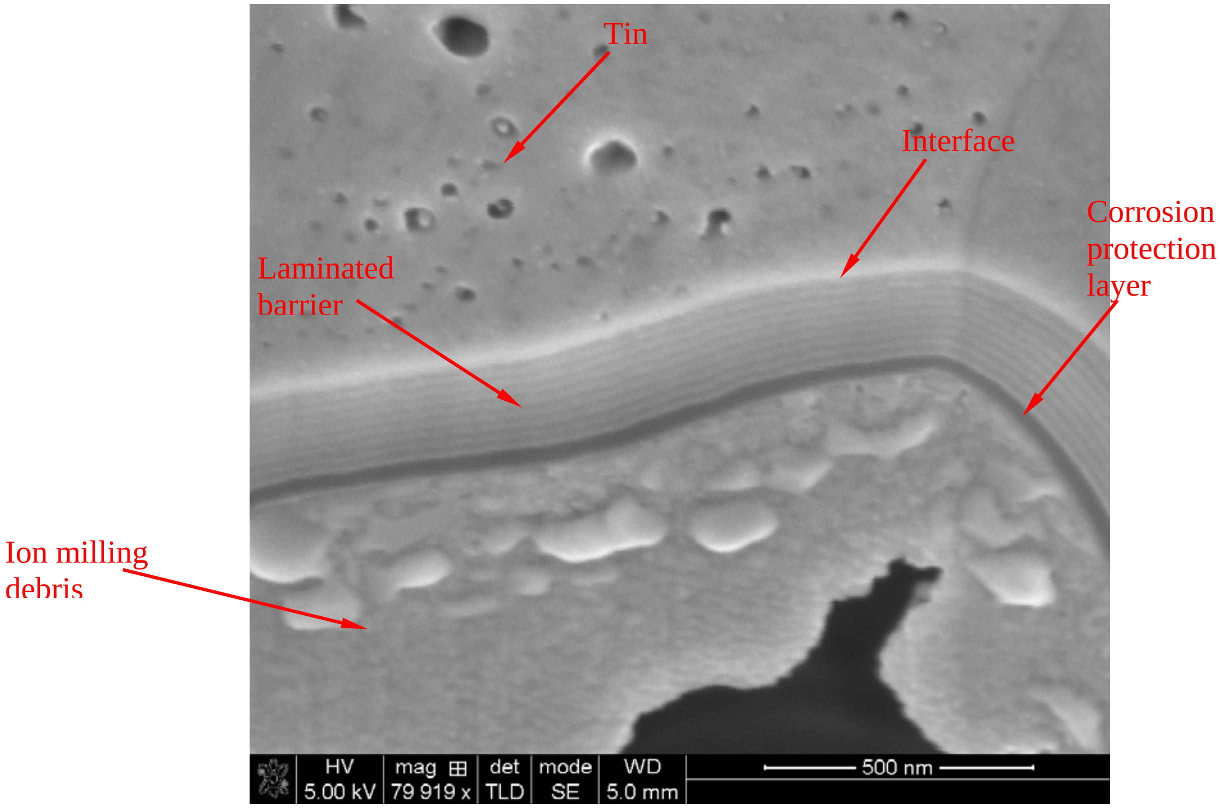

Fig. 1: FIB-cut SEM image shows the layer structure of a CCA (circuit card assembly) coated with 250 nm ALD-Cap.

High Productivity Process

Our ALD process is performed at low temperatures (down to 80° C) and at high deposition rates of 12 nm/min. Films in the range of 200-500 nm are required for demanding applications such as OLED protection and are regularly used. Sundew's *SMFD-ALD* patented equipment incorporates proprietary innovations that deliver high deposition rates at maintenance intervals longer than 350 μm accumulated film. This unique capability achieves high productivity at the lowest cost of ownership. Sundew's production equipment line currently includes fully automatic cassette-to-cassette wafer equipment, as well as industrial coaters for parts and components.