Junora LTD
ITO Target Development

June 16th, 2021, Junora LTD

Company Statistics

- Established as a C-Corp in May of 2017
  - 14 Employees
  - Most employees have 10+ years of target manufacturing experience
- Headquarters in Biddeford Maine
  - Additive manufacturing production system
  - Full Machine shop geared toward target and planar cathode manufacturing
  - Lithium planar and rotary target production equipment.
- R&D Laboratory in Tucson Arizona
  - TPD Additive manufacturing development system
  - Sputtering System to test and evaluate custom target materials
- Junora-Suzhou FICE established Q1 2019

Junora LTD Goals

- Provide the optimal products for our customer's applications by:
  - Focusing on solving core problems in sputtering processes
  - Innovating new target material manufacturing processes
  - Transitioning from single use to recyclable targets
  - Enabling the proliferation of new thin-film markets
  - Educating customers on how the manufacturing processes will affect their process performance and the cost of the product
  - Developing relationship with our customers
  - Manufacturing distributed regionally near customers to make target recycling economically viable

Core Technology Overview

CMC Process: Solid Wire → Liquid → Solid Target Material

- Direct deposition of lower vapor pressure metals directly onto backing tubes with a higher melting temperature than the target materials being deposited
- Grain structure controlled by the cooling rate of the melt pool
- Target materials can be reapplied after the target has been fully sputtered

TPD Process: Solid → Gas → Plasma → Solid Target Material

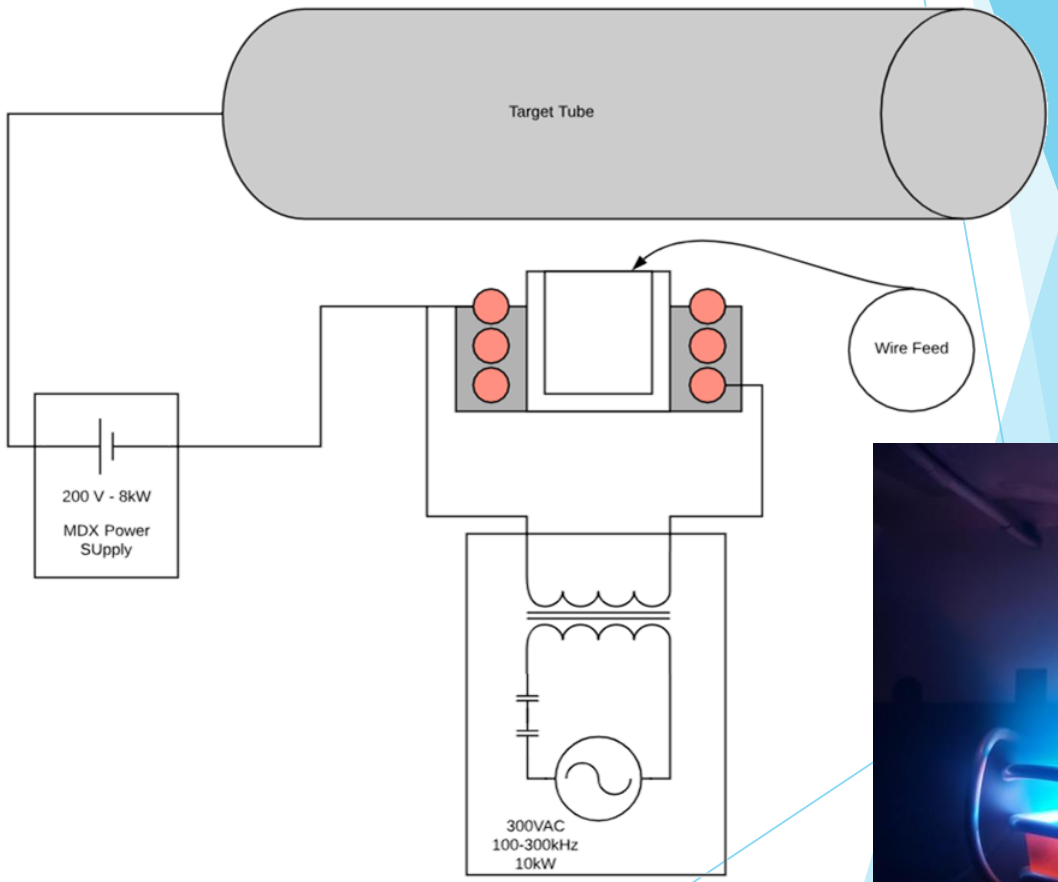
- **Direct deposition of higher vapor pressure metals and ceramics directly onto backing tubes**
- **Grain structure controlled using plasma voltage and target cooling rate**
- **Target materials can possibly be reapplied after target has been sputtered**

Flip Casting: Solid → Liquid → Solid Target Material

- Traditional casting process with in which the casting material is melted in one end of the vessel and then poured into the other using rotation
- Grain structure and alloy homogeneity controlled through cooling process
- Mature technology ready for production

Tech Overview: TPD Process in Detail

- Thermal Evaporation of deposition material using a induction power supply
- Supply of material into crucible using wire feed or hopper for powder or granules
- Excitation of plasma between crucible and target tube with DC, Pulse DC, HiPIMS, AC, or Bi-Polar Pulse DC depending on the desired material properties and ionization energies required
- Crucible height and position under the target is controlled remotely
- Deposition takes place directly above the crucible, rotation of the target tube and translation of the crucible along the length of the target enables coating of the entire target



Tech Overview: TPD Development System in Arizona

- Transverse stage moves the source under the rotating target tube
- Induction power supply located below the chamber and power is fed through flexible water-cooled silicon lines with copper conductors inside
- Oscilloscope used to monitor induction voltage and plasma activation
- Plasma Emission Monitor for process control and plasma analysis
- PLC Controlled Process

Primary Products

CMC

- Silver, tin, indium, lithium and other custom alloys

TPD

- **ITO, fine grain aluminum, copper, chromium, custom alloys, and other ceramics**

Flip casting

- Lithium, zinc, indium, tin, and any other metal or alloy with a melting temperature below that of stainless steel

Rotary Target Manufacturing Process Selection

Material	CMC	TPD	Flip Casting
Silver	D		
Lithium	T	T	X
ITO		D	
Tin	D		D
Copper	T	D	
Aluminum	T	D	
Chromium		D	
Cadmium Alloys		T	T
Zinc		T	T
Indium	D	D	D

Material	CMC	TPD	Flip Casting
AZO		T	
Bismuth	T		T
Gold	T		
Magnesium	T	T	
Cadmium		T	D
AlSc		T	

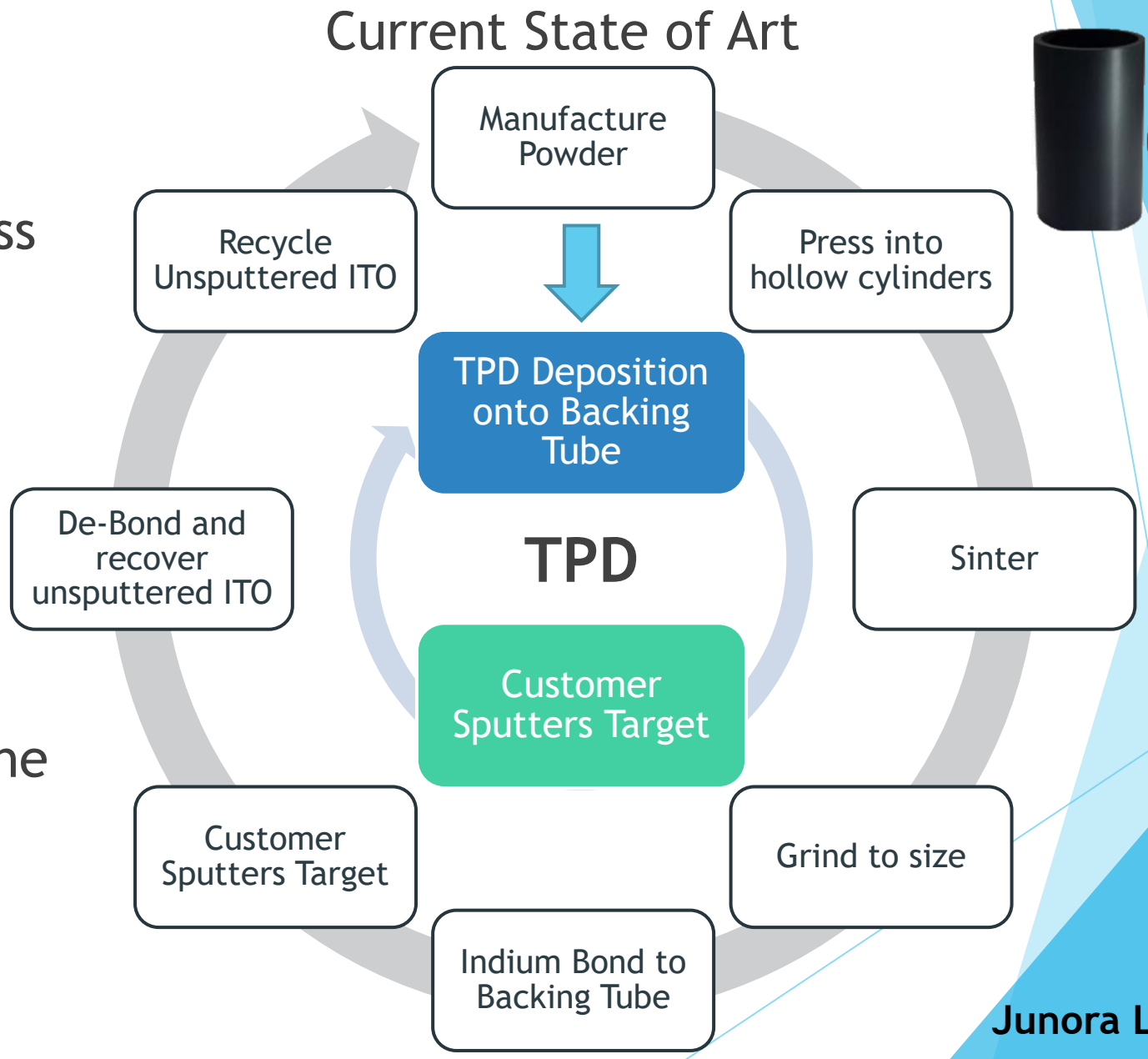
X = Ready for Production, D = in development, T = Theoretical

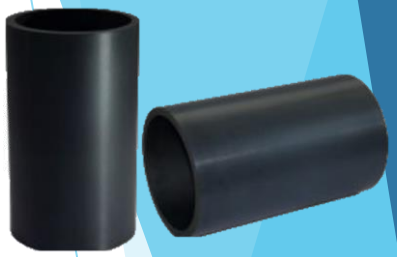
Primary Products: TPD Process Materials

- Aluminum optimized for reactive oxide deposition for display
  - Pure Aluminum with micron scale grain size to reduce arcing and maximize deposition rate
- Copper optimized for lower temperature deposition
  - Micron scale grain sizes reduces energy required to sputter copper and thus can reduce deposition temperatures on low temperature polymer substrates
- Indium Tin Oxide (ITO)
  - Directly deposited onto the backing tube to maximize deposition power and target cooling efficency
  - No bonding joints found on indium bonded targets can reduce arcing and debris
  - Controllable reduction of indium oxide to indium metal during the deposition process can broaden the deposition process operating window required to minimize the sheet resistance of the ITO coating
- Chromium deposition directly onto backing tubes with no gas incorporation

ITO Manufacturing Process Comparison

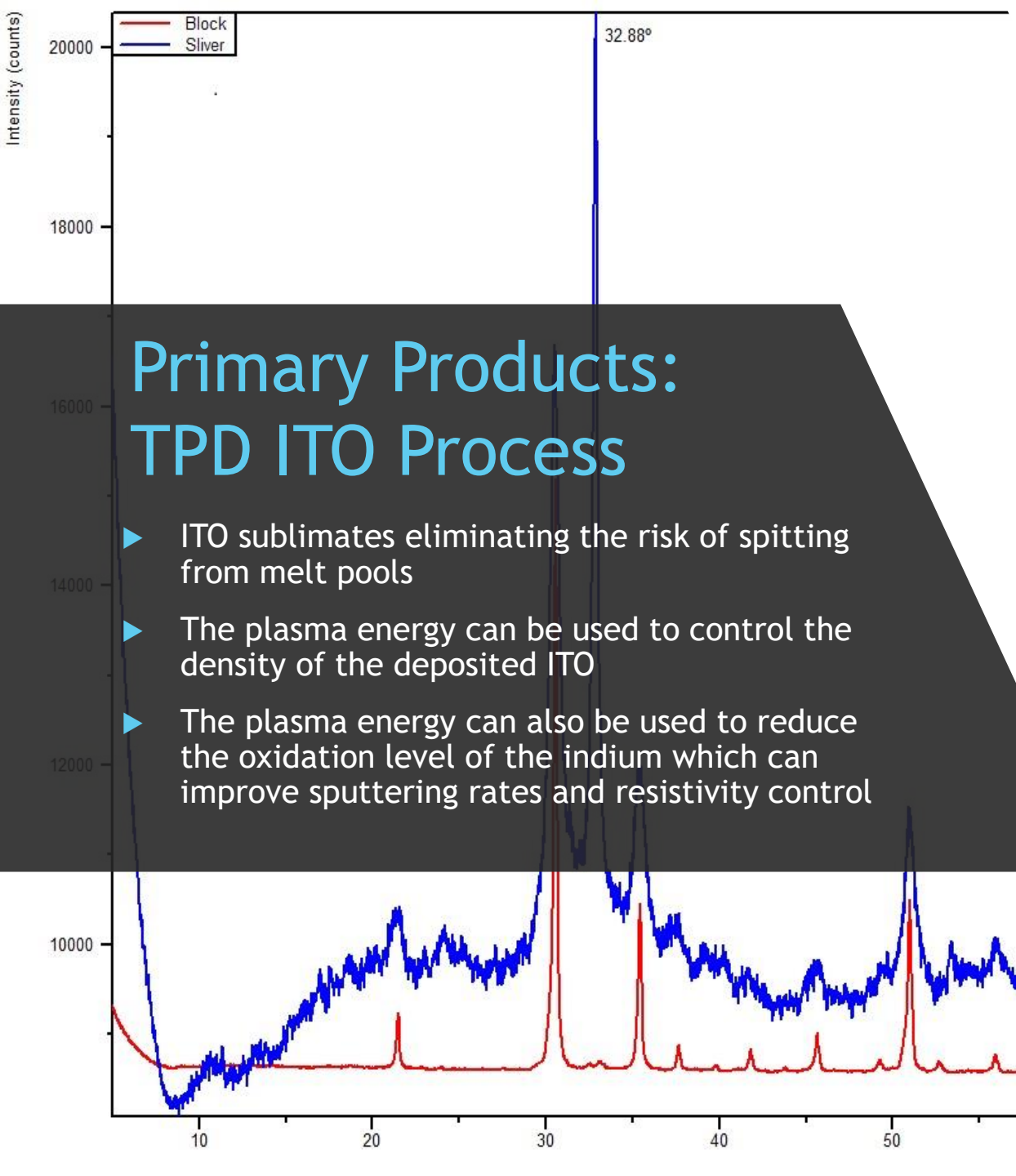
- Outside ring is the conventional ITO manufacturing process
- Inside ring is the TPD process
- New ITO needs to be added into the manufacture powder step on each cycle
- The TPD process eliminates many of the traditionally labor-intensive ITO target manufacturing steps





ITO Target Performance Comparison

Traditional Bonded ITO	TPD ITO
Power Limited by Indium Bonding	Not power limited, direct ITO to backing tube bond
Non-continuous material leads to arcing	Continuous target material for all length targets
ITO density can vary	ITO density continuous through entire target
Suboxide levels not easily controlled	Suboxide easily tunable
Gas contamination not easily controlled	Processed in vacuum chamber to eliminate gas



Primary Products: TPD ITO Process

- ITO sublimates eliminating the risk of spitting from melt pools
- The plasma energy can be used to control the density of the deposited ITO
- The plasma energy can also be used to reduce the oxidation level of the indium which can improve sputtering rates and resistivity control

ITO Development Plan

- Deposit ITO onto rotary target backing tubes with various plasma density and ion acceleration voltages
  - Measure ITO density
  - Measure oxygen reduction via XRD
- Sputter Deposited ITO in Test Chamber
  - Test resistivity as a function of density, oxygen reduction, and thickness
    - Measure the transparency
  - Test process stability as a function of power density
    - Measure deposition rate
    - Check for nodule growth at higher powers
    - Measure arc rate as a function of power density
    - Find maximum power limit that damage or nodules start to occur
- Make test targets for customers to qualify ITO deposition process on