

Atomic Layer Coating Technology for Enhancing Processability & Enabling Continuous Manufacturing for Challenging APIs

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AGENDA

ALC Technology Introduction

Pharmaceutical Applications

Processability Benefits

Summary

WHAT DO WE DO AT APPLIED MATERIALS...

Precision Materials Engineering

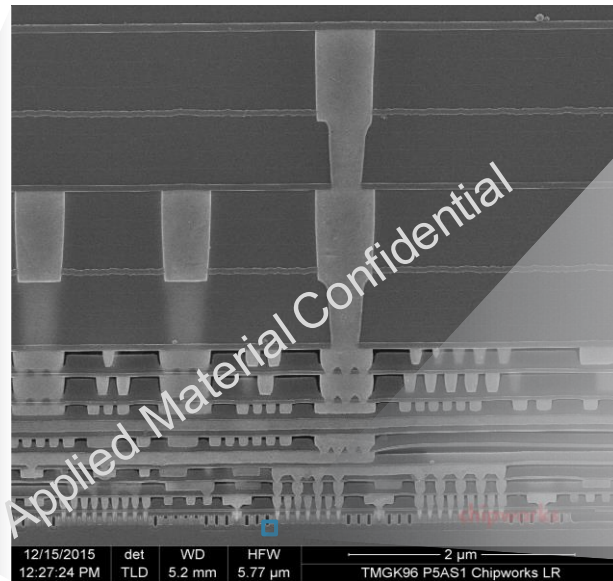
manipulating materials at an atomic level
on an industrial scale



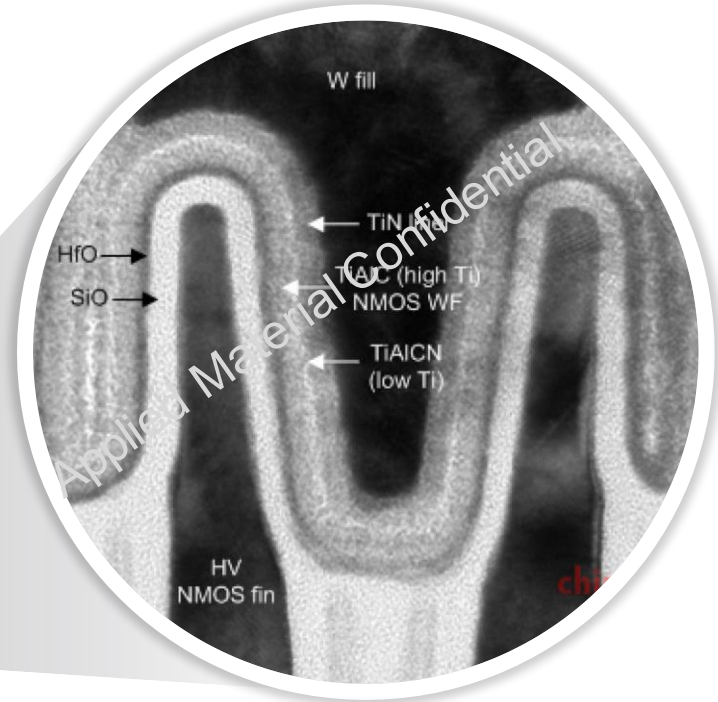
100mm



10mm



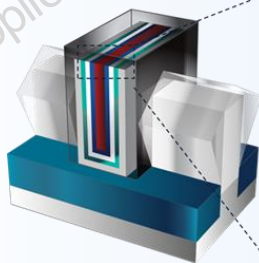
1μm



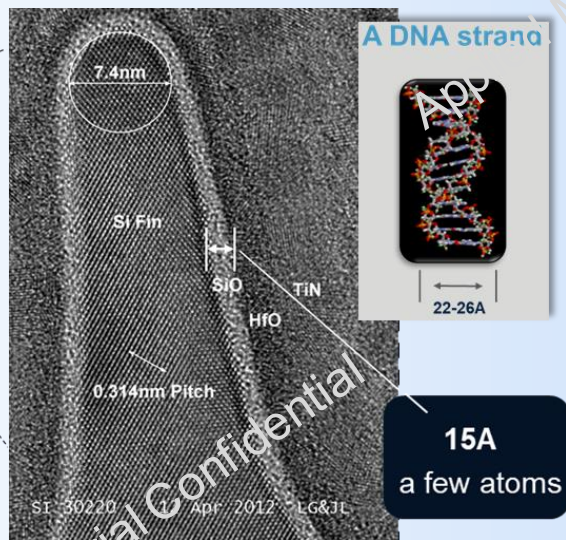
100nm

AMAT Surface Engineering Expertise

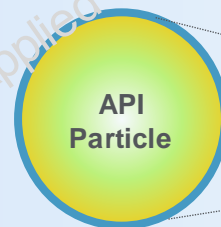
Atomic Layer Deposition in Semiconductor
(Billions of Transistors)



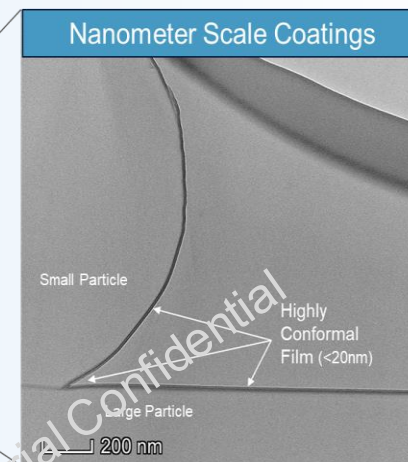
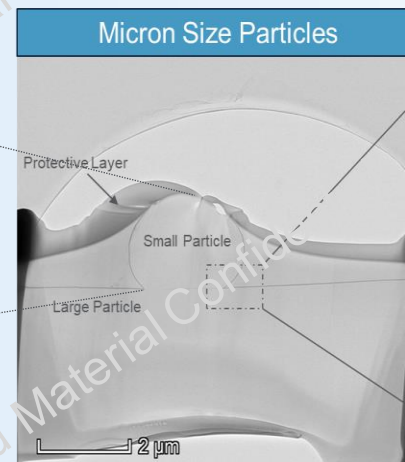
A FinFET Transistor



Atomic Layer Coatings in Pharma / Biopharma
(Billions of API Particles)



Conformal Nanoscale Coating on Particles



Developed for Microchips Fabrication:

- Multiple metal oxides
- Highly engineered and conformal, Pin-hole free
- Thickness control (0.1nm to 100nm)
- Ability to control composition including gradients
- Control electrical performance of the device

Developed for Pharma/Biopharma Drug Products:

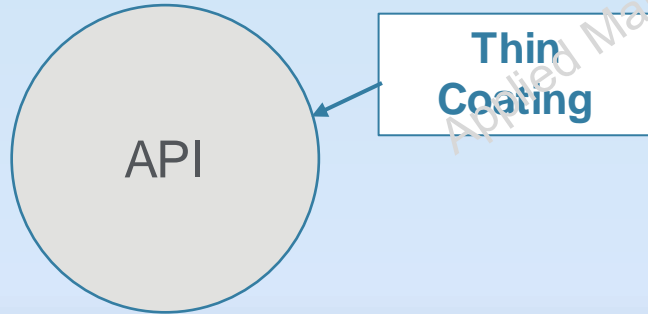
- Application specific composition (AlOx, SiOx, ZnOx)
- Highly engineered and uniform coating
- Precision thickness control
- Tailored composition, thickness to coating function
- Developing **coatings for product-specific applications**

Applied Materials *Phalcon*TM Technology Platform

SCALABLE vapor phase deposition
technology capable of growing thin films on the
surface of the API enabling improved
PROCESSABILITY and tailored drug product
FUNCTIONALITY

Role of Atomic Layer Coatings for Pharma API

API Processability

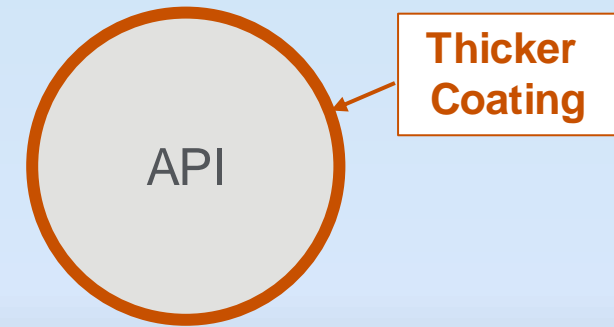


COATING : Thinner Coatings

FUNCTION : Remove Surface Charge,
Minimize Agglomeration

APPLICATIONS : Improves Flowability & Stability
Enables Direct Compression,
Continuous Manufacturing

API Functionality



COATING : Thin/Thick Coatings; Multilayer Coating

FUNCTION : Improved Stability,
Controlled Release

APPLICATIONS: Retain Amorphous State
Extended Release,
Increase Shelf-life

COMBINED PROCESSABILITY AND FUNCTIONALITY BENEFITS CAN BE ACHIEVED WITH
COATING ENABLED FORMULATIONS

Atomic Layer Coating Enabled Formulation Benefits

PROCESSABILITY

Powder Sticking and Rat Holing



Agglomeration

UNCOATED

ALC COATED

Improved Handling of Poorly flowing API



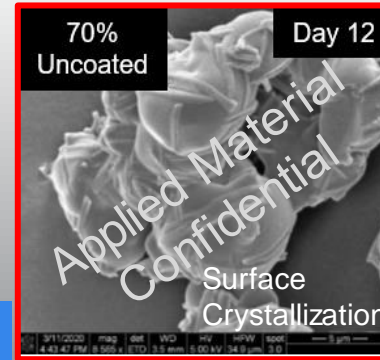
No Agglomeration

STABILITY / BIOAVAILABILITY

70% API+30% Polymer

Crystallizes 40C/75% RH

Day 12



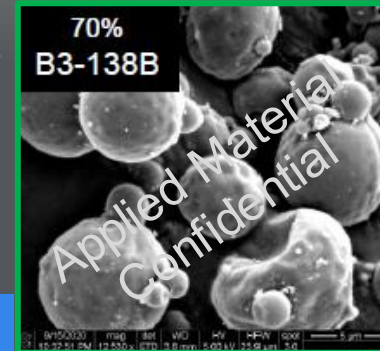
UNCOATED

ALC COATED

70% API+30% Polymer

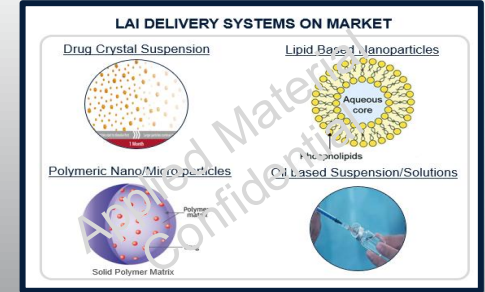
Remains Amorphous 40C/75% RH

Day 180



LONG ACTING INJECTABLES

API Specific Delivery Vehicles

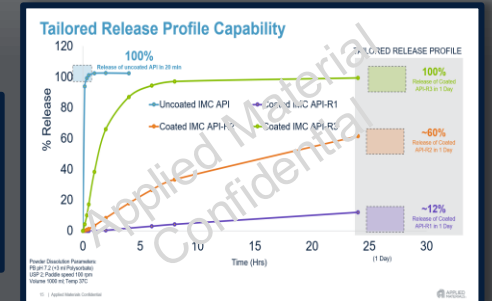


Multiple Formulation Steps

UNCOATED

ALC COATED

Universal Delivery Platform



Single ALC Coating Step

Flowability Improvement → Processability Advantage

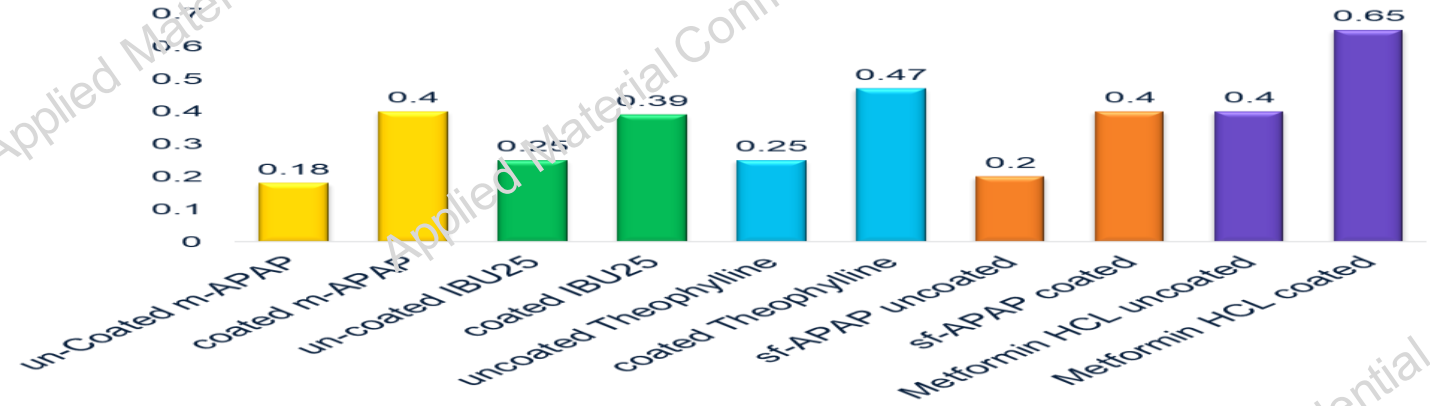
Uncoated mAPAP



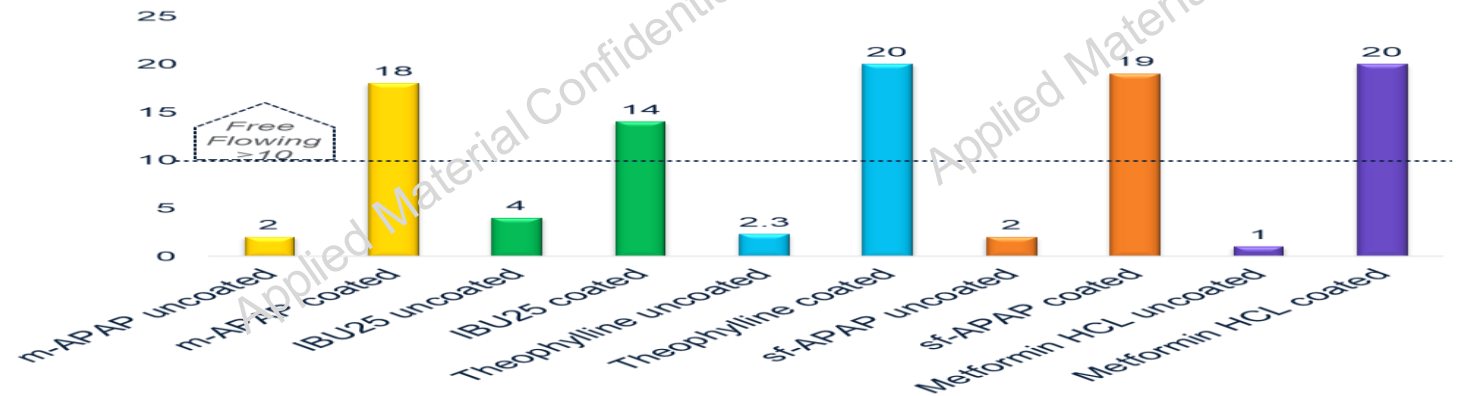
Coated mAPAP



Bulk Density



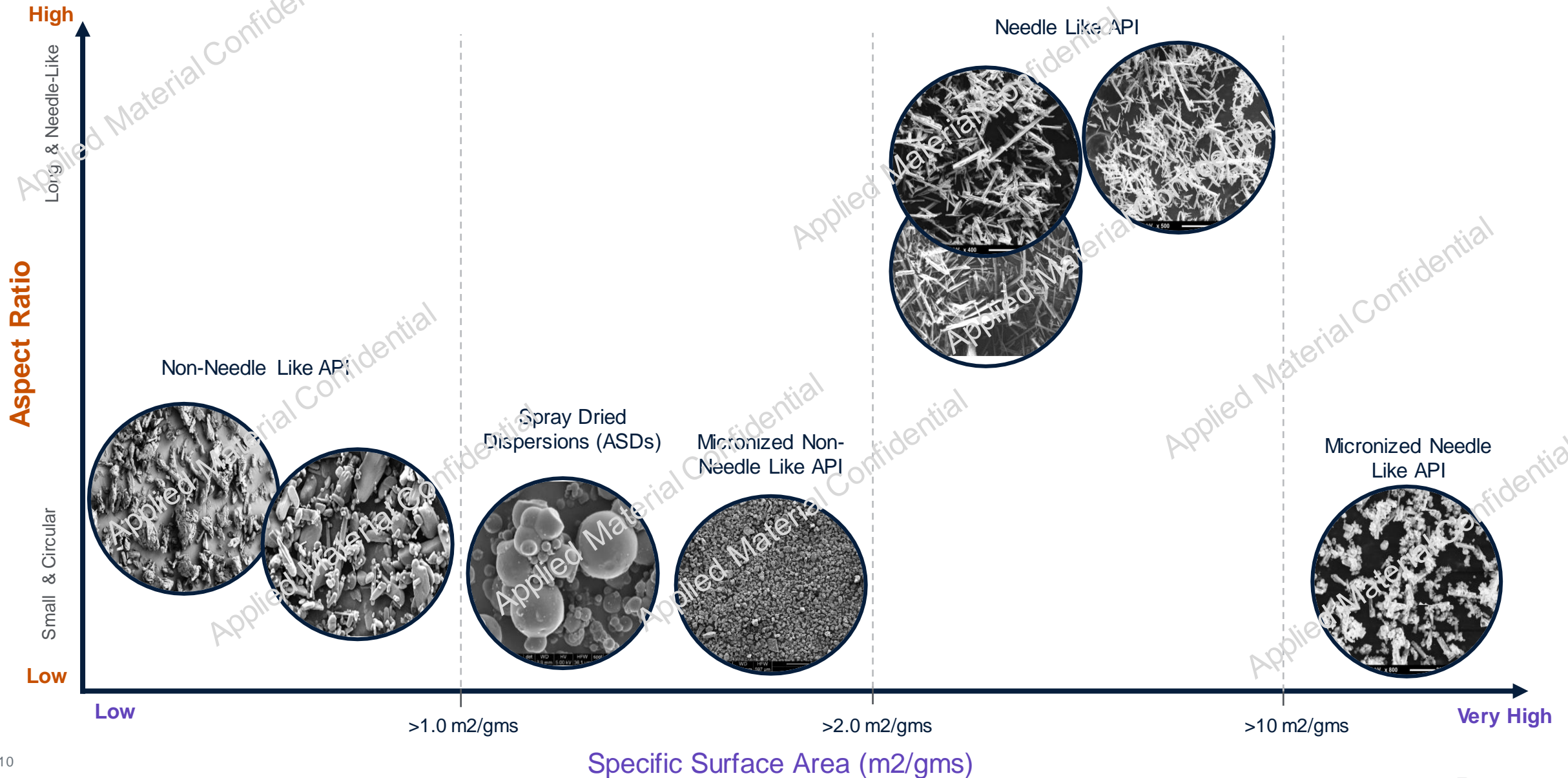
Flow Function (FFc)



Atomic coating requires a few nanometer of coating to change powder behavior

From poorly flowing to free flowing

Particle Morphologies & SSA Coated by ALC Technology



Summary ALC Benefits

ATOMIC COATING+ API



- **IMPROVED FLOW**
- **IMPROVED BULK DENSITY**
- **REDUCED VOID VOLUME**
- **SURFACE MODIFICATION (HYDROPHILICITY, HYDROPHOBICITY, CHARGE)**

PRODUCT DEVELOPMENT



- **FEWER UNIT OPERATIONS → SIMPLER FORMULATIONS**
- **FEWER INACTIVE INGREDIENTS**
- **FEWER D-E/D-D COMPATIBILITY & STABILITY ISSUES**
- **DRUG RELEASE MODIFICATION**
- **BIOAVAILABILITY IMPROVEMENT**
- **SHORTER DEVELOPMENT TIMELINES**

COATING ENABLED FORMULATIONS

MANUFACTURING



- **HIGHER POSSIBILITIES FOR CONTINUOUS MANUFACTURING**
- **FEWER SCALABILITY ISSUES**
- **FEWER UNIT OPERATIONS**
- **SHORTER BATCH MFR. TIME**
- **LESS INACTIVE(S) & TESTING COSTS**
- **LESS STORAGE SPACE & SHIPPING COSTS**
- **HIGHER PRODUCTIVITY**

PATIENT



- **LOWER DOSAGE FORM SIZE**
- **SIMPLER PILL BURDEN**
- **TASTE MASKING POTENTIAL**
- **IMPROVED MEDICATION ADHERENCE**



APPLIED
MATERIALS®

make possible