IBED Coated Tooling Helps Improve Tableting Efficiency and Productivity

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An increasing number of manufacturers of solid dose tablets are gaining improvements in tableting efficiency and productivity by using high-performance coatings on tablet punches and dies. The coatings are designed to reduce wear and corrosion on the working surfaces of the tooling, which in-turn helps maintain the original surface finish on the tooling and dramatically slows the development of sticking and picking. The choice of the type of coating and the coating process are critical and influence the degree of performance enhancements obtained.

Wear and Corrosion Degrades Tool Performance and Life

Tableting tooling will perform at optimum levels when the surfaces in contact with formulation powders are highly polished and free of surface scratches, pits, and corrosion products (Figure 1). Unfortunately, industry-standard tool steels such as D-series, S-series, and stainless steels (408, 440C) are all prone to abrasive wear and corrosion. As the working surfaces of the punches and dies roughen from wear and corrosion, a number of physical phenomenon occur which act to reduce tableting productivity and increase manufacturing costs.

Increased Mechanical Interlocking

When scratches and pits develop in tooling surfaces, the powders can become trapped in these mechanical surface imperfections (Figure 2). As additional tablets are compressed, the powders will stick to the particles trapped in the surface and start to build-up on the surface. Eventually, sticking and picking appear, and production must be halted to clean the punches. Likewise if surfaces corrode, and rust layers build on the punch surface, powders will begin to stick to the roughened rust layers. Cleaning with detergents or solvents will remove the adhered powders but will not restore the original finish of the tooling surfaces. Buffing may be required to polish out scratches and pits, and remove corrosion products, in order to restore the original surface finish.

Increased Friction Between Powders and Punch/Die Surface

Roughened surfaces will also increase frictional forces as powders flow across the punch faces and in the dies during compression. Predetermined concentrations of lubricants and glidants will no longer be effective. Higher compression forces may be required and the work of ejection will increase.

Reduced Tool Life

Constant restoration of worn and corroded punch faces by buffing and polishing has a significant negative impact on tool life. Buffing compounds contain abrasives that actually remove thin

layers of the metal surface in order to polish-out scratches and pits. Repeated buffing can reduce the critical punch dimensions in the land area at the punch tip thus degrading the fit between the punch and die. Constant buffing also results in rapid degradation of the aspect ratios of embossed features on the punches. In both cases the usable life of the punch is dramatically reduced.

Wear and corrosion are direct contributors to reducing tableting productivity and increasing the cost of manufacture of solid dose tablets. Since the base metals currently used for tableting tooling are optimized for the mechanical conditions encountered in tableting operations, performance coatings, if chosen and applied properly, offer an excellent mechanism for improving wear and corrosion resistance.

IBED Coatings Can Help

Ion beam enhanced deposition (IBED) is a new coating process that can be used very effectively to coat tableting punches and dies with a variety of hard, wear- and corrosion-resistant coatings. IBED coating technology is ideal for use on tableting tooling because; 1) coatings can be applied at temperatures that do not exceed 150 degrees Fahrenheit thus maintaining critical tooling dimensions and bulk hardness; and 2) the original surface finish of the tooling is replicated exactly.

Unlike conventional electroplating or high-temperature vacuum coating processes, IBED is a physical as opposed to a chemical or thermal process. IBED processing combines the benefits of thermal diffusion processing and conventional coating technologies because the coating atoms first penetrate into the substrate to form a case layer in the surface, and then are grown out from this case layer as a thick coating. Driven in kinetically instead of thermally, IBED coatings are "ballistically bonded" to the substrate thus forming a metallurgical bond that is much stronger than a mechanical or chemical bond.

The IBED coating process implemented by the simultaneous bombardment of a growing coating with an independently controllable beam of energetic atomic particles (see Figure 3). The growing coating is generated either by vacuum evaporation or ion beam sputtering. The independent beam of particles consists primarily of charged atoms (ions) extracted at high energy from a broad beam ion source. Beams of either inert species (Ne^+, Ar^+, or Kr^+) or reactive species (N^+ or O^+) can be utilized. Because control of the ion beam is independent of the coating vapor flux, a high degree of control over coating nanostructure can be achieved. This allows optimization of coating properties such as adhesion and composition, and guarantees that the properties can be duplicated repeatably. Essentially a line of sight process, sources of the reactant fluxes are located so that they simultaneously illuminate the components to be coated (see Figure 4). The components are mounted to an angling, rotating platen assembly that is used to uniformly expose all surfaces of the components to both reactant fluxes.

A variety of types of metallic and hard ceramic coatings can be deposited on the working surfaces of punches and dies. The metallic coatings include chromium and nickel, and the ceramic coatings include metallic nitrides like titanium nitride and chromium nitride. For most tableting applications the family of hard ceramics is the coating of choice. They are much harder and abrasion-resistant than nickel or even chromium, and provide a corrosion-resistant seal on all

coated surfaces. Because of the hardness and durability of the coatings, the wear and corrosion experienced during normal tableting operations does not degrade and roughen the tooling surface and the tableting tooling performs better and longer. If powders begin to stick because of physio-chemical adhesion, the coated surfaces can be cleaned with detergents, solvents, or mild abrasives without the risk of scratching or roughening the original surface finish. The use of IBED performance coatings offers an excellent way to preserve the critical surfaces of punches and dies thereby improving tableting efficiency and manufacturing productivity.

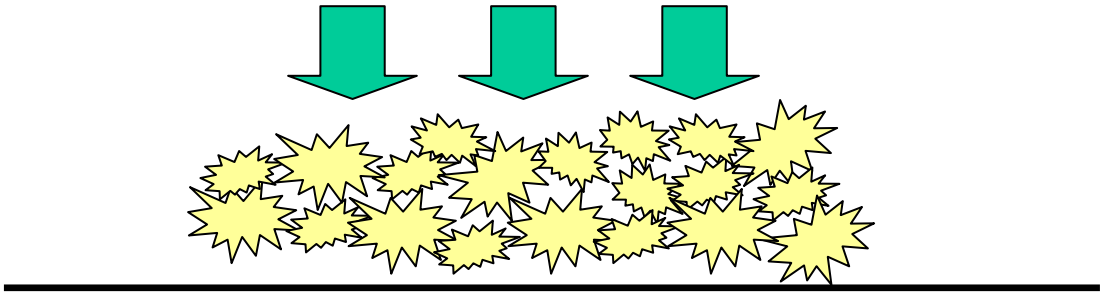

Figure 1. Powders compressed against a smooth polished surface show no mechanical interlocking with the surface and sticking and picking are minimized.

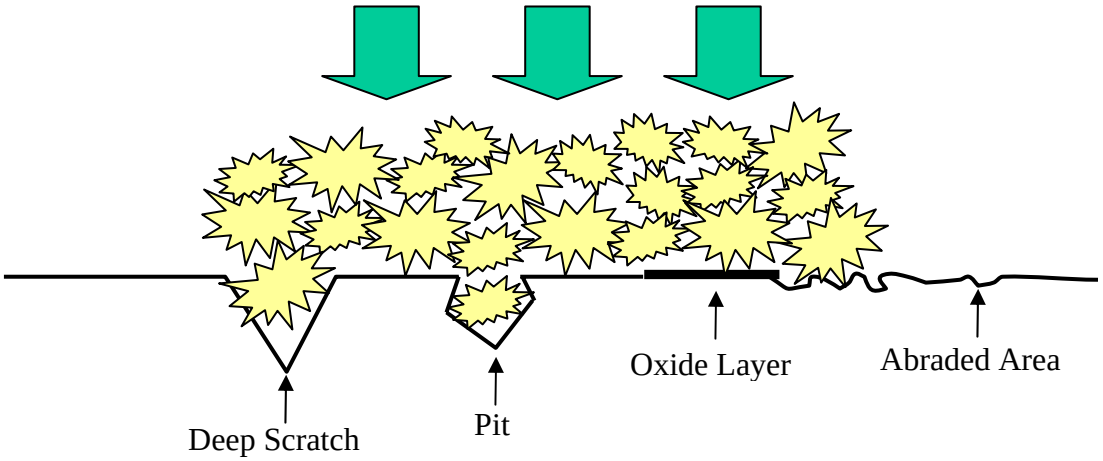

Figure 2. Powders compressed against a roughened surface can become trapped in scratches and pits causing powder build-up, eventually leading to sticking and picking.

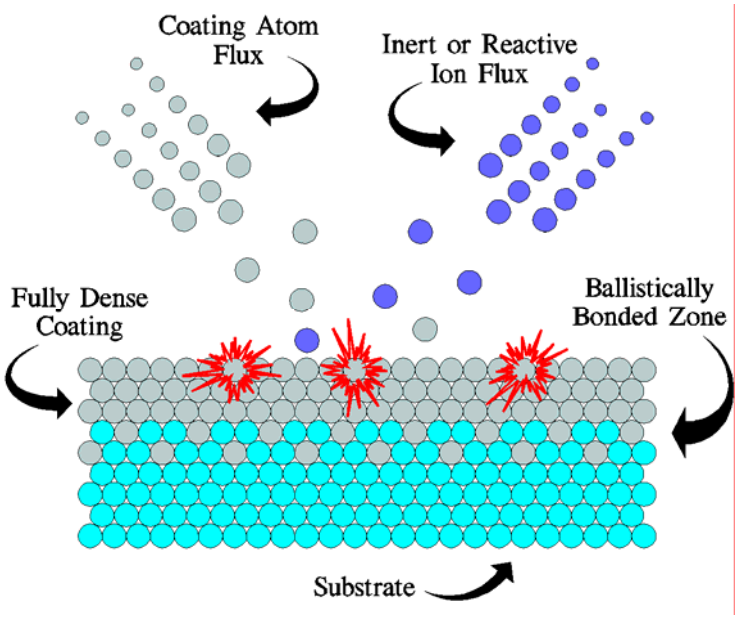

Figure 3. IBED coatings are deposited by vapor depositing a coating on the punch surface and augmenting the coating adhesion and growth with an energetic ion beam. Processing is done in a vacuum chamber at temperatures that do not exceed 150 degrees Fahrenheit.

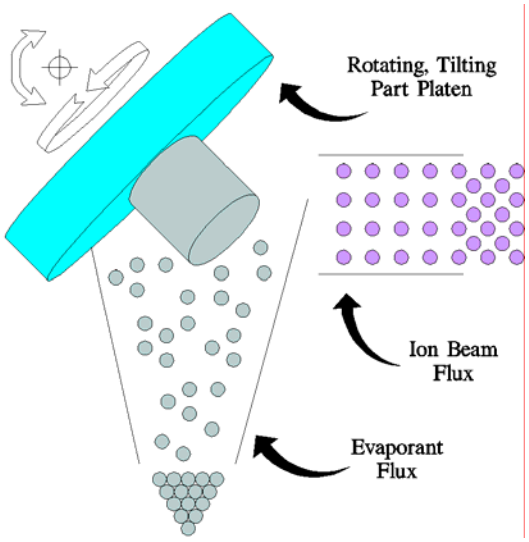

Figure 4. Punches and dies are mounted to a rotating, tilting part platen that allows the coatings to be deposited uniformly on all tooling surfaces, including all embossed features.