



## Metal Nitrides (MN<sup>3-</sup>)

### Properties

A nitride is a compound of **nitrogen** where nitrogen has a formal oxidation state of  $-3$ . Nitrides are a large class of compounds with a wide range of properties and applications <sup>[1]</sup>. Nitrides of refractory metals have high lattice energy which reflects the strong attraction of "N<sup>3-</sup>" for the metal cation. Nitride compounds often have large band gaps. Metal nitrides have high hardness and wear resistant/corrosion resistant (Ti-N, Zr-N, Cr-N, Ta-N et al). They can also be used as magnetic (Sm-Fe-N, Fe-N), semiconductor (Ga-N, Al-N), and battery (Co-Li-N) materials.

### Plating Solutions

Molten salts are, in general, chemically and physically stable, highly electrically conductive, and in many cases, they dissolve various chemical species with sufficiently high concentration. Moreover, they have wide electrochemical windows; for example, in the case of alkali halides, the accessible potential range is as wide as between alkali metal deposition (cathodic limit) and halogen gas evolution (anodic limit). Metal nitride films can be electrodeposited by using the reduction of ammonium ions in molten salts, for example chromium nitrides (Cr<sub>2</sub>N) can be plated in LiCl-KCl eutectic mixture, containing ammonium ions (NH<sub>4</sub>Cl) and chromium cations (CrCl<sub>2</sub>) at 723 K <sup>[2]</sup>. Surface nitriding of various metals and stainless steels is possible by the use of anodic reaction of nitride ion (N<sup>3-</sup>) in LiCl-KCl-Li<sub>3</sub>N melts <sup>[3]</sup>.

Ionic liquids can be used for the deposition of metal nitrides. For example, the electrochemical deposition of GaN can be performed from NH<sub>4</sub>Cl and GaCl<sub>3</sub> in an ionic liquid (1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)amide ([Py<sub>1,4</sub>]Tf<sub>2</sub>N) <sup>[4]</sup>.

### Applications

Metal nitride films are used as a surface protection material, a semiconductor material, an optical material, a magnetic material due to their physically and chemically excellent characteristic. For example, TiN is used as cutting material and in hard coatings. TaN is used as diffusion barrier for copper metallization in semiconductor technology. GaN is used for emitting blue light in LED's. Nitrides can also absorb hydrogen to be used for hydrogen storage, e.g. lithium nitride.

### References:

1. M.N. Greenwood and A. Earnshaw, *Chemistry of the Elements* (2nd ed.). Butterworth-Heinemann. 1997.
2. T. Goto, A. Niki, H. Tsujimura, and Y. Ito. *Proc. Electrochem. Soc.* PV 2004-24, 964-969, 2004.
3. Y. Ito and T. Nishikiori. *J. Min. Met.* **39**(1-2) B, 233-249, 2003.
4. A. Lahiri, N. Borisenko, and F. Endres. *Chem. Commun.* **50**, 10438-10440, 2014.

**CONTACT NANO3D SYSTEMS LLC TO FORMULATE METAL NITRIDES PLATING  
SOLUTION PER YOUR REQUIREMENTS**