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The Platinum Group Metals as Coating Materials

How precious is your metal - An overview on the use of the platinum group metals as contact surfaces for electronic connectors.

- **Platinum**
- **Palladium**
- **Rhodium**
- **Ruthenium**
- **Iridium**
- **Osmium**
- **Adsorption**
- **Frictional Polymer**

The next issue of Technical Tidbits will discuss silver as a coating material.

The platinum group metals consist of platinum and palladium, as well as rhodium, iridium, osmium, and ruthenium. They can be found in the transition metals on the periodic table of the elements. A close-up of this part of the table is shown in Figure 1. Palladium is currently the only metal of the group in widespread use in electrical contacts, although platinum was widely used in the past. Rhodium is only used in electrical contact applications requiring very high hardness and wear resistance. The other three metals in the group are used mainly in other industrial applications.

Pure, electroplated **platinum** and **palladium** have a hardness of around 200 to 400 HV, although they may also be applied by cladding. Both have a conductivity of around 16% IACS. Thus they are harder than gold, but slightly less conductive. At one time, their prices were competitive with gold, and gold-flashed palladium coatings were even used as less expensive alternatives to gold coatings. However, both of these metals are much more expensive than gold (at least at the time of this writing). Due to its cost, gold-flashed palladium is now used mainly in applications which require greater hardness and wear resistance than hard gold alone.

Rhodium is much harder than platinum and palladium, typically 800-1000 HV, with an electrical conductivity of 38% IACS. This makes it the most electrically conductive of the platinum group metals. It is also exceptionally corrosion resistant, although it is also brittle when plated. It is used for applications requiring very good wear resistance and high hardness, such as switches, brush contacts, and certain contact probes.

For reference, **ruthenium** is slightly harder and less conductive than rhodium, typically showing 900-1100 HV, with 23% IACS. Pure **iridium** has 32% IACS conductivity. Although it is not typically electroplated, its hardness is estimated around 600-800 HV. These two metals are also noted for their exceptional hardness and corrosion resistance. However, they are mainly used as hardening agents in platinum and palladium based contact alloys. Multiple references indicate that **osmium** produces a toxic oxide at room temperature (OsO_4), although OsO_2 is not toxic. No mention is given of the dosage by which it is said to be toxic, however. Regardless it will not likely be found in electrical contacts, but is mainly used when alloyed with other elements.

26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper
44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver
76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold

Figure 1. The platinum group and related metals.

The Platinum Group Metals as Coating Materials (continued)

Like gold, platinum and palladium alloy coatings require a nickel undercoat to act as a barrier against diffusion and corrosion migration. In rhodium plated contacts, a hard nickel underplate may be necessary to help prevent cracking of the harder, more brittle layer of rhodium.

In arcing contacts, palladium may be used as a pure metal, or alloyed with silver. Platinum would usually be used as a pure metal. However, according to the references at the right, the number of arcing contact applications for these metals is rapidly dwindling, due to the rise of solid state relays and more advanced, arc-resistant contact materials. There will be more discussion of arcing and arcing contacts in upcoming editions of Technical Tidbits.

In non-arcing electrical contacts, palladium is commonly alloyed with nickel or cobalt. These coatings have higher hardness, lower residual stress, and better ductility than pure palladium. There are also many proprietary alloys of palladium available, composed of such common alloying elements as gold, silver, copper, nickel, etc.

Platinum and palladium are noted for their tendency to catalyze reactions. This is an advantage in automotive catalytic converters, where these and other metals have been used to convert hazardous NO and CO into N_2 and CO_2. In electrical contacts this tendency can be a distinct disadvantage, if there are organic vapors in the surrounding air. These kinds of vapors are common industrial pollutants found in the atmosphere. They may also be generated by outgassing from the connector's plastic housing when it is heated. (This heat may be generated by electrical arcing from contact switching, by the resistive power dissipation of the contact interface, or even by nearby components.) These organic vapors are attracted to platinum and palladium contact surfaces, which have a tendency to catalyze chemical reactions. The vapors will physically deposit and react with each other on these surfaces, through a process called **adsorption**. This results in the formation of brown, powdery organic films on the surface. These films are known as **frictional polymer**, and can disrupt the electrical contact. Thankfully, an inert gold flash on the palladium surface is usually sufficient to prevent the formation of these films.

Despite the fact that it they are not used as widely as they once were, palladium and its alloys are still important contact materials. They possess good corrosion resistance and better hardness than gold. Platinum and rhodium still have their uses as well, in certain niche applications. Even though interest in some of these metals as coatings for electrical contacts is mostly academic, they are still worthy of some discussion, and no discussion of electrical contact materials would be complete without them.

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