Gold Plating Thickness of Connectors and Contacts

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Proper specification of gold plating thickness for connector and contact applications is a key design consideration. Gold plating is an exceptional finish for connectors of that demand both high reliability and durability; however, the thickness of the gold plating will impact the durability and ultimate cycle life of the connector. Gold plated connectors have low contact resistance which is suitable for applications with low signal voltages and current in the millivolt and milliamp range. Because gold is a noble metal, it does not readily react with chemicals in most environments, meaning that gold plated connectors will retain their conductivity over time provide the thickness of the gold provides a sufficient barrier to the substrate from the environment.

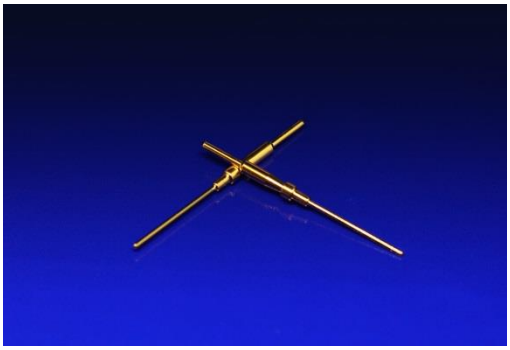
Due to the high cost of the precious metal, gold plating of connectors is typically deposited in very thin layers of 5uin to 100uin (0.1um-25um) with respect to other plated metals. However, gold can be plated to thicknesses as high as 500uin to 1000uin (12.5um to 25um) in extreme cases. As the thickness of the gold is increased both the corrosion resistance and wear resistance of the gold plated connector increases. When connectors are plated with a very thin "flash" gold deposit (less than 10uin, 0.25um) the gold is a very porous. The gold plating may look continuous but there are thousands of microscopic pores in the deposit making it more like a thin screen of gold rather than a continuous pore-free layer. Although the gold plating may not readily react to corrosive environments, the pores in the gold provide a path to the base material which will allow the substrate to oxidize and corrode through the gold.

One method to increase both the corrosion protection and wear resistance of gold connector is to increase the thickness. As the gold plating thickness increases the pores in the deposit become reduced in size and quantity. Eventually as the thickness continues to increase the pores in the gold plating will become completely closed creating a pore-free gold layer. When gold plating is truly pore-free it provides exceptional barrier corrosion protection preventing corrosive attack of the material. However, due to the cost of gold, it is important to balance the functional requirements of the plating against the specified gold thickness to provide the most cost effective gold plated connector or contact.

Thin Plated Gold Connectors or Contacts (4-20uin or 0.1-0.5um)

For gold connectors used in a controlled environment with minimal wear considerations, common gold plating thickness is between 4-20uin (0.1-0.5um). Thin gold layers in this range can provide low contact resistance as well as excellent solderability/wire bonding while consuming a minimal amount of gold. This is a common thickness for static gold contacts that do not repeatedly cycle or slide during use. Examples include grounding nuts or studs, fixed contacts or solder pads.

Moderate Thickness Gold Plated Connectors or Contacts (30-50uin or 0.75-1.25um)



For a connectors and contacts with moderate environmental and wear cycles, common functional gold thickness range between 30-50uin (0.75-1.25um). The increase in gold thickness to this level provides greatly improved corrosion resistance over that of thin gold or gold flash plating. In addition, thicknesses in this range offer moderate to good wear resistance for dynamic connector or contacts that cycle during use. Although the gold plating is not typically pore-free at these moderate levels, the thickness of the gold is sufficient to provide some barrier to corrosion in moderate environments that do not have repeated condensation cycles or the potential for corrosive chemical attack. Examples of components plated in this range of thickness include male/female pins/sockets, phosphor bronze or beryllium copper flex contacts or gold plated contact springs.

High Thickness Gold Plated Connectors or Contacts (Greater than 50uin or 1.25um)

For applications where the highest corrosion protection and wear resistance are required, heavier gold deposits of 50uin (1.25um) or more are typically required. Depending on base material and surface finish of the connector, 100uin (2.5um) or more of gold plating is required to develop a fully pore-free layer that will provide the best barrier protection against corrosion of the base material. Gold plating of contacts or connectors greater that 50uin is common of mil-spec and Oil & Gas interconnect applications that are exposed to more aggressive environments as well as thermal and switching cycles. Heavier gold deposits in this range provide sufficient material to allow for very high cycle applications of 10,000 cycles or more when properly engineered with the proper underplate.

Underplate Considerations for Gold Plated Connectors

A nickel underplate is typically recommended for most gold plated connectors or contacts especially if the substrate is a copper or copper alloy. Nickel serves several key functions as follows:

- **Diffusion Barrier:** Copper and alloying elements such as zinc and lead can diffuse into the gold plating through solid state diffusion creating a weak intermetallic or eutectic at the gold/substrate interface. This consumes some of the effective gold and reduces the integrity and function of the deposit. A nickel underplate forms an effective barrier against the mobility of diffusion at the gold/substrate interface.
- **Levelling Layer:** A nickel underplate can act as a levelling agent which can produce a surface finish with lower roughness which can reduce friction, thereby increasing the wear protection of gold plated connectors or contacts.
- **Load Bearing Layer:** A nickel deposit is a hard plated layer that provides a foundation for the subsequent gold plating to be deposited upon. This can prevent cracking of hard gold deposits and improve the overall wear resistance of gold plated connectors or contacts that are used in dynamic cycling.
- **Corrosion Inhibitor:** Nickel underplates can serve as an effective corrosion inhibitor by working in tandem with the final gold plated layer to seal the base material from the environment. This can help reduce the overall gold thickness required to prevent corrosion of the substrate

through a gold deposit. Nickel underplates such as high phosphorous electroless nickel provide outstanding corrosion resistance whereas high purity nickels such as a sulfamate nickel provide the best soldering base. As such, the type of nickel and thickness of the nickel should be carefully considered as a key element in the overall design of a gold plated connector and contact.

The thickness of the nickel underplate can vary based upon the design requirements of the connector or contact. However, a minimum thickness of 50uin (1.25um) is typically recommended to provide some of the benefits listed above.

Solderability Considerations for High Gold Thicknesses

It is important to note, as gold plating thickness increases past 50µin, the solder joint can experience embrittlement due to the diffusion of gold into the solder joint. Gold is a very mobile metal when in contact with the tin alloys commonly used in soldering. In low levels the gold does not have a deleterious impact on the strength of the joint. However, at higher thicknesses of gold, sufficient gold is present to cause embrittlement of the solder joint. 3% is commonly cited as the maximum gold allowable within a solder joint prior to significant embrittlement occurring[1]. As such, the thickness of the gold as well as the amount and type of soldering should all be considered when specifying the thickness of the gold plated contact or connector. This is of high concern for applications where vibration of the solder joint is a design consideration.

Summary of Common Thicknesses for Gold Plated Connector or Contacts

Table 1 below provides a summary of the various gold thicknesses for gold plated connectors and contacts along with a cross reference to common specifications and an application reference. Note that the thicknesses in this table are intended as a reference only. Due to the diversity of applications and uses of gold plating, thorough evaluation and testing is necessary to ensure the deposit meets all design requirements.

Table 1: Common Gold Plating Thickness for Functional Gold Use

Common Thicknesses of Gold	Relevant ASTM B488 Class	Relevant MIL-G-45204 Class	Applications
10µin 0.25µm	Class 0.25	N/A	Suitable for static connections in controlled environments without cyclical use. Good for solderability and wire bonding (10-20uin)
30µin 0.75µm	Class 0.75	Class 0	Good for connections that may be soldered. Contacts can be exposed to moderate environments and wear cycles but not high cycle or chemical attack.
50µin 1.25µm	Class 1.25	Class 1	Suitable for connections that may be soldered, exposed to more aggressive environments, offers superior protection against wear in moderate to high cycles.
100µin 2.5µm	Class 2.5	Classes 2	Not recommended for connections that may be soldered, offers excellent protection against corrosive environments and durability high wear applications

Technologies to Enhance Performance of Gold Connectors and Contacts

Advanced Plating Technologies offers several gold plating technologies to enhance the corrosion resistance and durability of gold plated contacts including duplex gold and APT-PST™. In duplex gold plating both hard and soft gold layers are plated in series to provide a net-reduced porosity gold deposit that could be provided with a single layer system. APT-PST™ is a post-plate process embeds a unique molecule into the microscopic gold pores providing greatly enhanced corrosion resistance and lubricity over untreated gold plating of a like thickness. This process can be used to reduce gold thickness/cost as well as increase the performance of a gold or duplex gold deposit to meet demanding design requirements. A member of APT's engineering staff can provide more information on these processes.

Gold offers a wealth of desirable properties when plated on connectors and contacts including low contact resistance, consistent conductivity over time, corrosion protection and solderability. The thickness of the gold plating is a key design consideration since thickness impacts the properties and durability of the gold deposit. This article is a brief over view of some of the most common aspects to consider when selecting the finish for a gold plated connector. For any additional information please feel free to contact a member of Advanced Plating Technologies engineering group at sales@advancedplatingtech.com or 414.271.8138.

References:

1) Glazer, J. Kramer, P.A., and Morris, J.W., Jr.; *Effect of Au on the Reliability of Fine Pitch Surface Mount Solder Joints,* United States Department of Energy, 1991