High Phosphorus Electroless Nickel for Selective ENIG (SENIG)

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The Process

If you break open a cell phone today you will find circuit boards that have a mix of final finishes on the same board. One side or area will have components soldered to it where there had once been an organic solderability preservative (OSP), and another area will have ENIG where the contact pads for the phones key pad are. The reason for this is that assemblers are more comfortable attaching BGA's to OSP surfaces than they are to ENIG surfaces.

The problem for board manufacturers in this scenario is that the mixed package boards can be a manufacturing headache. The application of two final finishes means that the boards must have a dryfilm applied after soldermask application and developing, to the areas where we don't want the ENIG to go. The dryfilm must survive the 180+°F baths of the nickel and gold on the ENIG line. The ENIG that has been deposited on the copper areas that were not covered by the dryfilm must be able to stand up to the stripping chemistry used to remove the dryfilm and also survive the subsequent OSP cycle with its attendant cleaner and microetch. (See figures 2, 3 and 4).

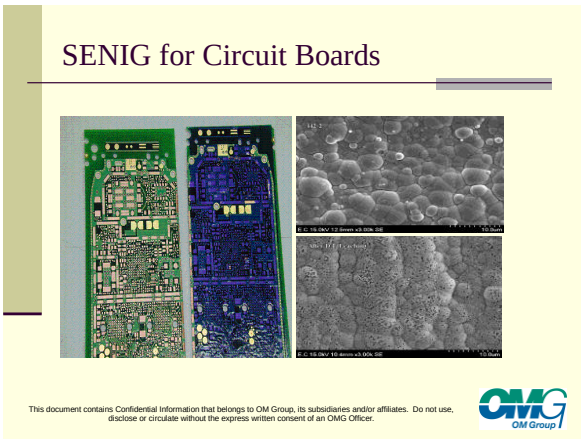

Figure 2

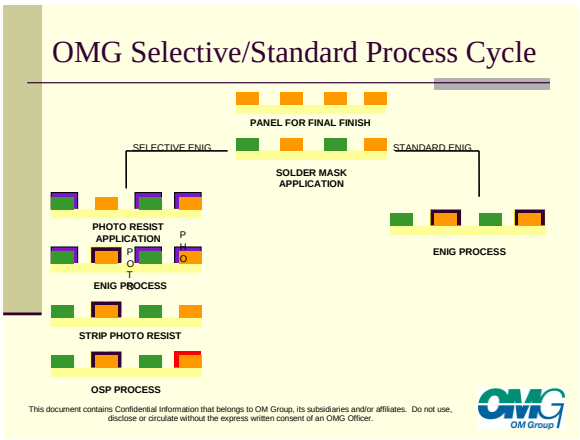

Figure 3

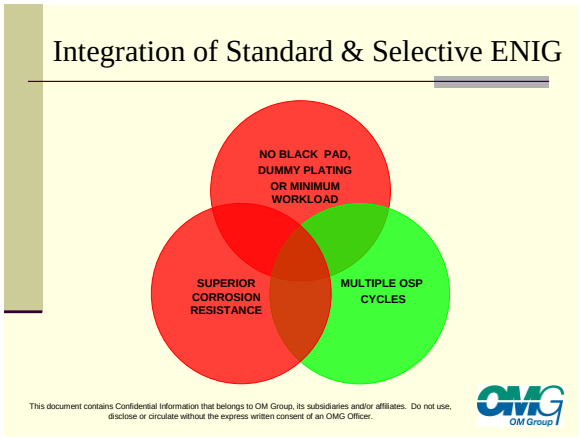

Figure 4

Current Problems

The major problem seen today is the effect that the dryfilm has on the nickel bath. Due to the high heat of the nickel bath it leaches out components of the dryfilm which have a strong stabilizing effect on the nickel once the bath reaches ~ 2 metal turnovers (MTO's). This obviously drives running costs through the roof as normal nickel bath lives typically reach 5 MTO's. There is of course the added cost of pre-mature waste treatment as well.

In order to avoid having to waste treat nickel baths at less than their "normal" 5 MTO's some production mangers/supervisors try to stage their SENIG work to run it when their ENIG lines have run non SENIG work to 2-3 MTO's. The SENIG would then be run from 3 MTO's to 5MTO's and the poisoning of the nickel bath would be moot as the bath would be ready to be dumped any way.

There are other problems associated with the current SENIG processes, such as the need to dummy plate and susceptibility of the fairly porous gold layer. The resist stripper and acidic cleaner and microetch on the OSP line can sometimes penetrate the gold and attack the underlying nickel surface causing corrosion.

TESTING METHODS TO DEVELOP A SUPERIOR PROCESS FOR MANUFACTURING

A SENIG process that can have the following ADVANTAGES would be of great value:

- No dummy plate
- No minimum bath loading
- 5 MTO's of bath life
- Corrosion resistance of gold and nickel (Figure 5)
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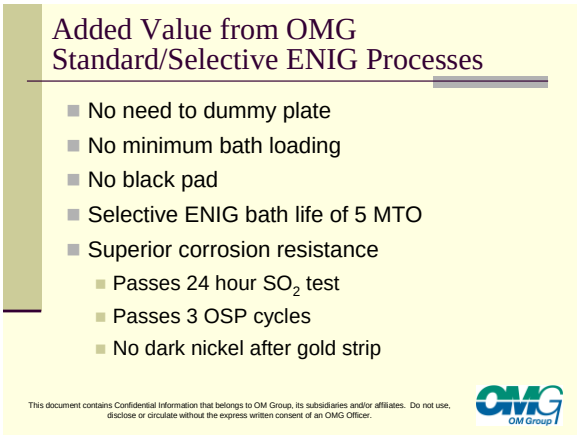


Figure 5

In running the SENIG (Figure 7) there were certain test pieces prepared and a specific test that was developed by an OEM for corrosion testing. (Figure 8)

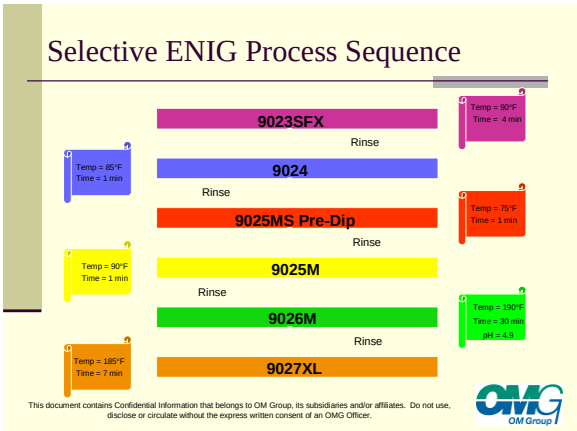


Figure 7

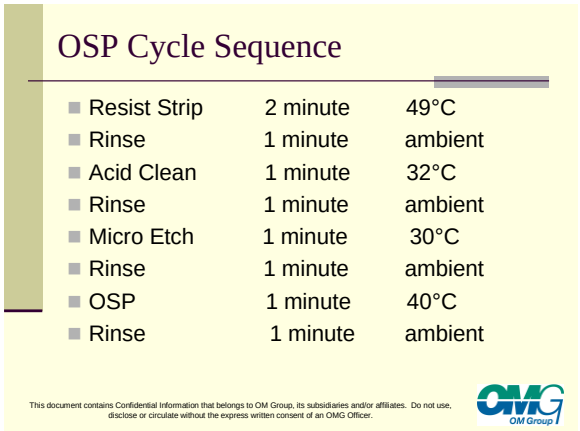


Figure 8

The SO_2 test exposes the SENIG surface to 24 hrs of a corrosive vapor at 107°F. The vapor will penetrate normal ENIG coatings and compromise the nickel surface (Figures 8 – 11). The corrosion can be very severe and even when minor it will cause gold peeling which tape testing will show. While the test pieces coated with dryfilm were being run the nickel bath showed that there was a component of the dryfilm being leached into the bath but a specific additive within the nickel formula prevents the over-stabilization of the nickel.

OSP Cycle Sequence

Resist Strip	2 minute	49°C
Rinse	1 minute	ambient
Acid Clean	1 minute	32°C
Rinse	1 minute	ambient
Micro Etch	1 minute	30°C
Rinse	1 minute	ambient
OSP	1 minute	40°C
Rinse	1 minute	ambient

Figure 9

SO_2 Corrosion Test

Procedure

- Ultrasonic clean samples with acetone
- Place in Desiccator
- 10 ppm SO_2
- 24 hours
- 42°c

Criteria

- Corrosion hole diameter (mm)
  - >0.4 1
  - 0.12 to O.4 <15
  - 0.05 to 0.12 -
  - Total corrosions <30

Figure 10

Failure After 24 hr SO^2 Test

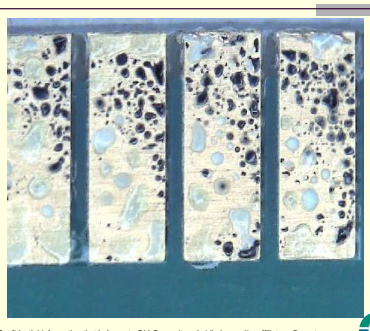


Figure 11

24 Hour SO_2 Corrosion Test Results

0 MTO 5 MTO

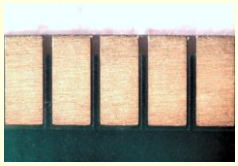


Figure 12

The morphology of the nickel deposit remains constant across the 5 MTO's of nickel bath life. (Figures 13 – 16). Even after three OSP cycles (to simulate rework cycles), the surface was not attacked or corroded.

Absorbance Levels vs Nickel MTO's

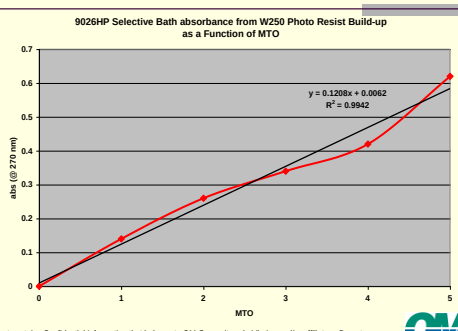
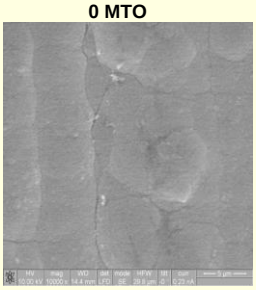


Figure 13

Surface Morphology After 3 OSP Cycles

0 MTO **1 MTO**



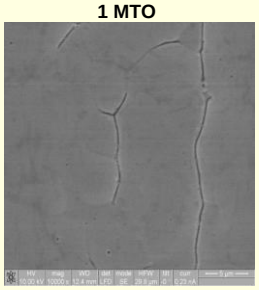


Figure 14

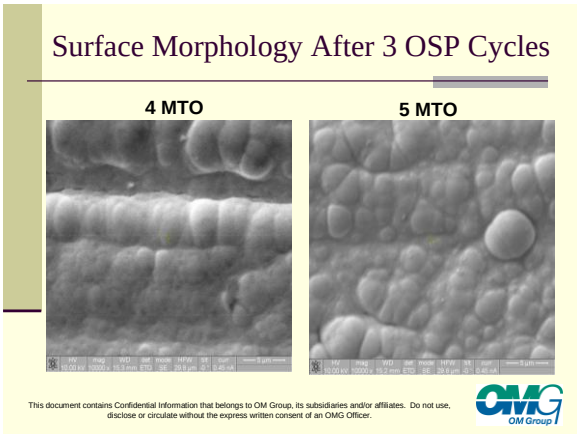


Figure 15

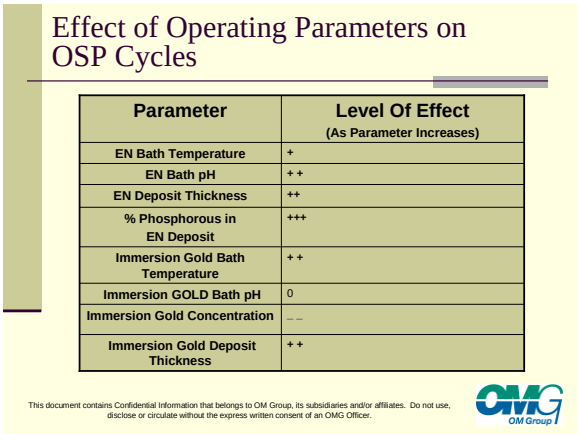


Figure 16

The characteristics of the plating rates of the nickel and gold did see some fall-off (Figures 17 – 20) but remained within acceptable production time and through-put parameters.

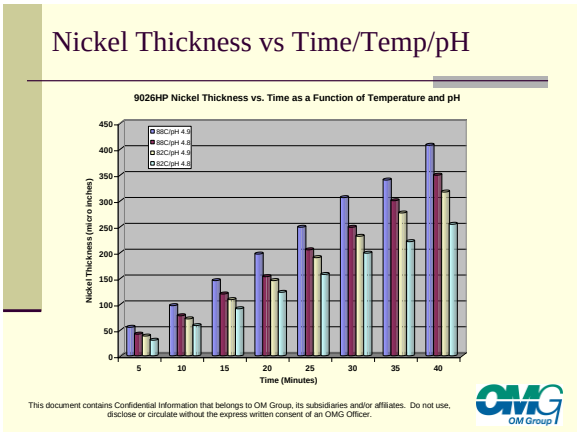


Figure 17

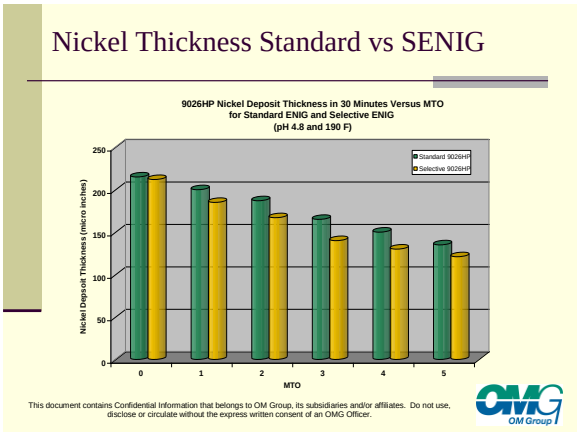


Figure 18

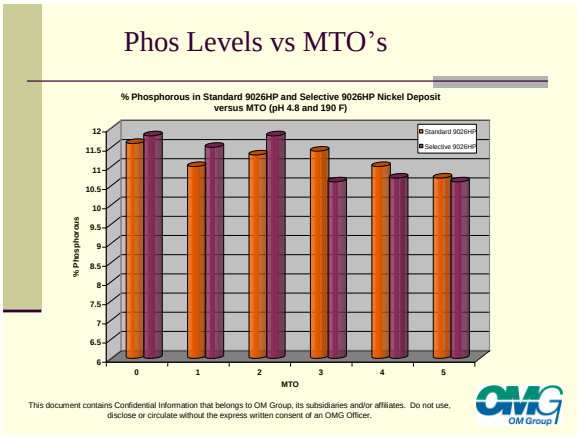


Figure 19

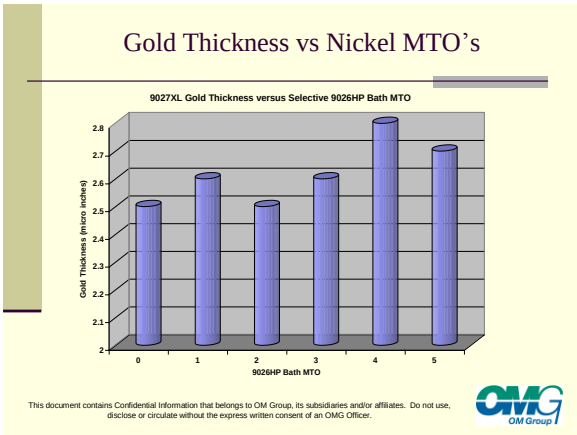


Figure 20

SUMMARY

Concerns

There are some areas that must be accepted if planning to run the newest SENIG process:

- Slower plating rate in nickel (to get 150µ" it will take 20 minutes)
- It works better at higher temperatures (190°F is best operating temp)

It has higher phosphorus in the deposit (as high as 11.7%) and some evidence suggests solderability may be reduced at such levels; we have an extensive solderability study on-going.

Advantages

It is possible to have a high phosphorus nickel bath last to 5 MTO's while running SENIG. The obvious advantage of longer bath life is also bolstered by other benefits:

- No dummy panels
- No minimum loading
- No corrosion from stripper or OSP cycles
- Pass SO_2 testing

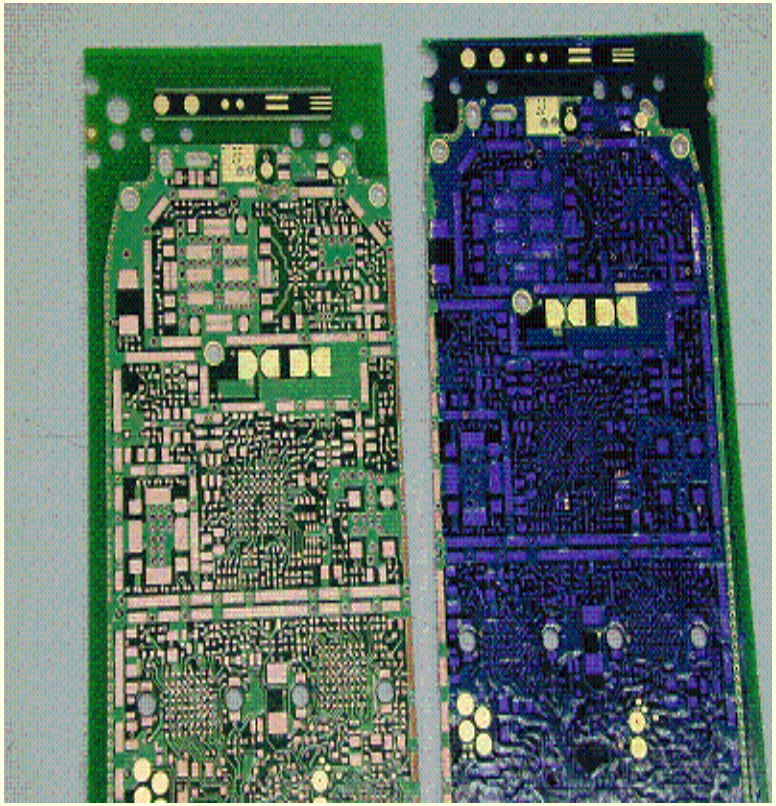
IPC Las Vegas 2008

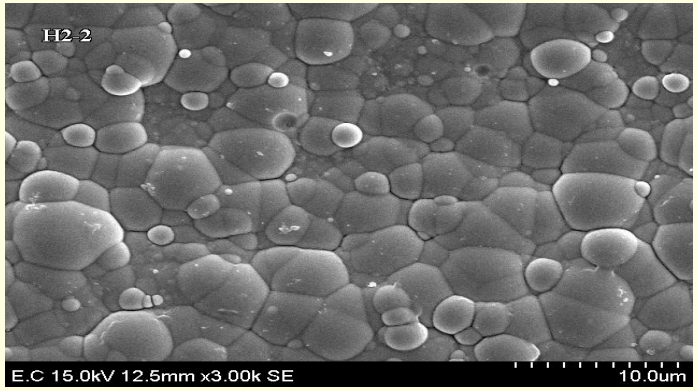
HPEN for Selective ENIG

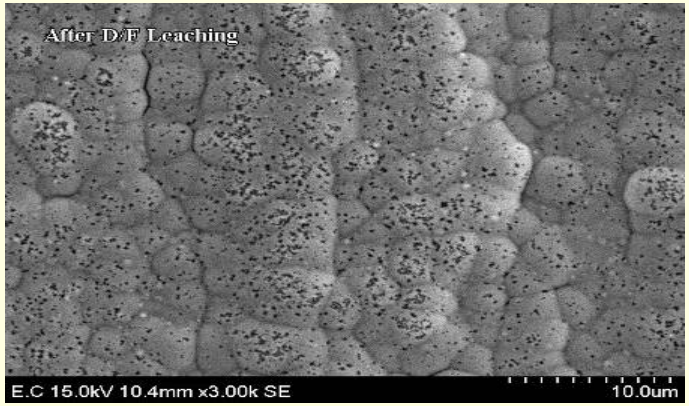
MK Walsh

OM Group

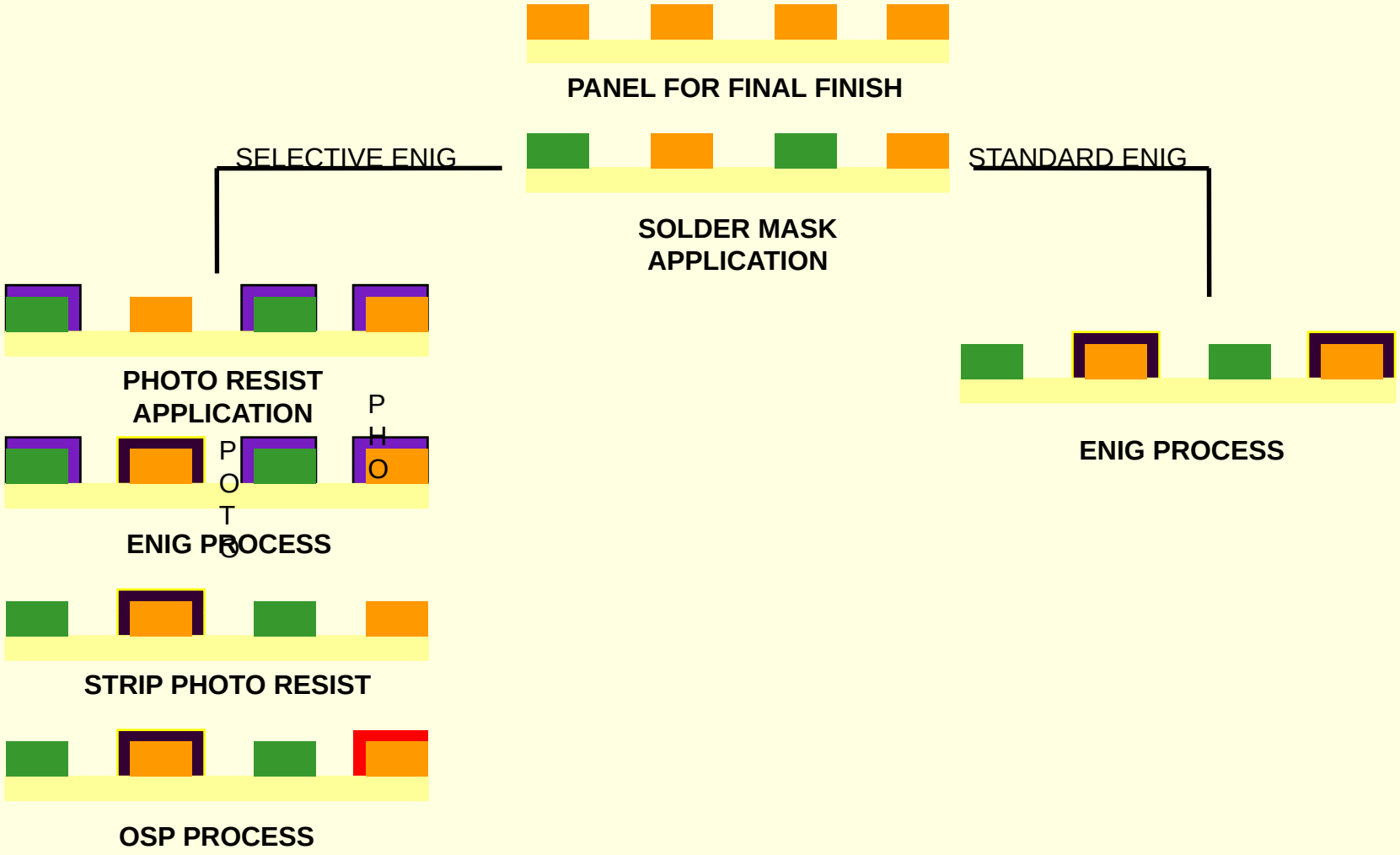
SENIG for Circuit Boards



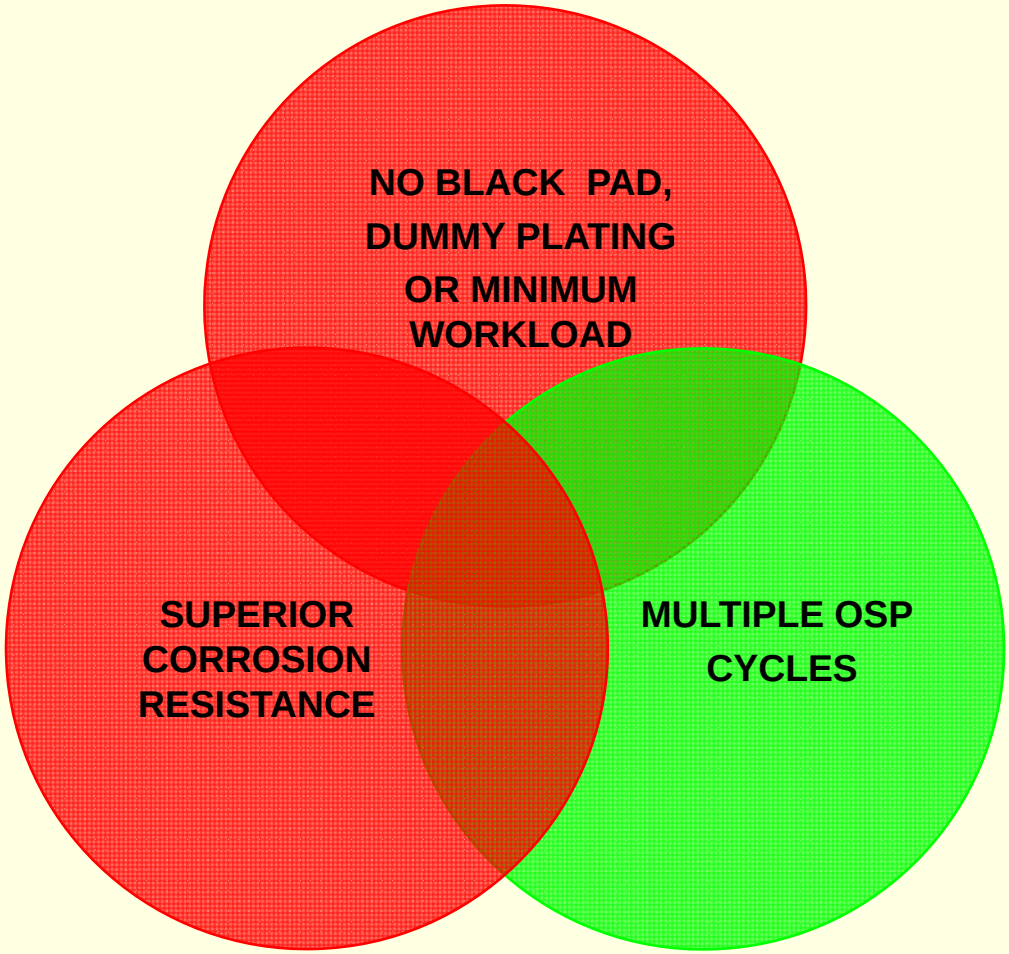




OMG Selective/Standard Process Cycle



Integration of Standard & Selective ENIG



Added Value from OMG Standard/Selective ENIG Processes

- No need to dummy plate
- No minimum bath loading
- No black pad
- Selective ENIG bath life of 5 MTO
- Superior corrosion resistance
  - Passes 24 hour SO_2 test
  - Passes 3 OSP cycles
  - No dark nickel after gold strip

Selective ENIG test vehicle conditions

- Electroplated copper laminate
- Copper area
  - 0.15 ft^2/gallon
- Photo resist area
  - 0.6 ft^2/gallon
- Ratio (photo resist to copper)
  - 4 to 1

Selective ENIG Process Sequence

OSP Cycle Sequence

Resist Strip	2 minute	49°C
Rinse	1 minute	ambient
Acid Clean	1 minute	32°C
Rinse	1 minute	ambient
Micro Etch	1 minute	30°C
Rinse	1 minute	ambient
OSP	1 minute	40°C
Rinse	1 minute	ambient

SO_2 Corrosion Test

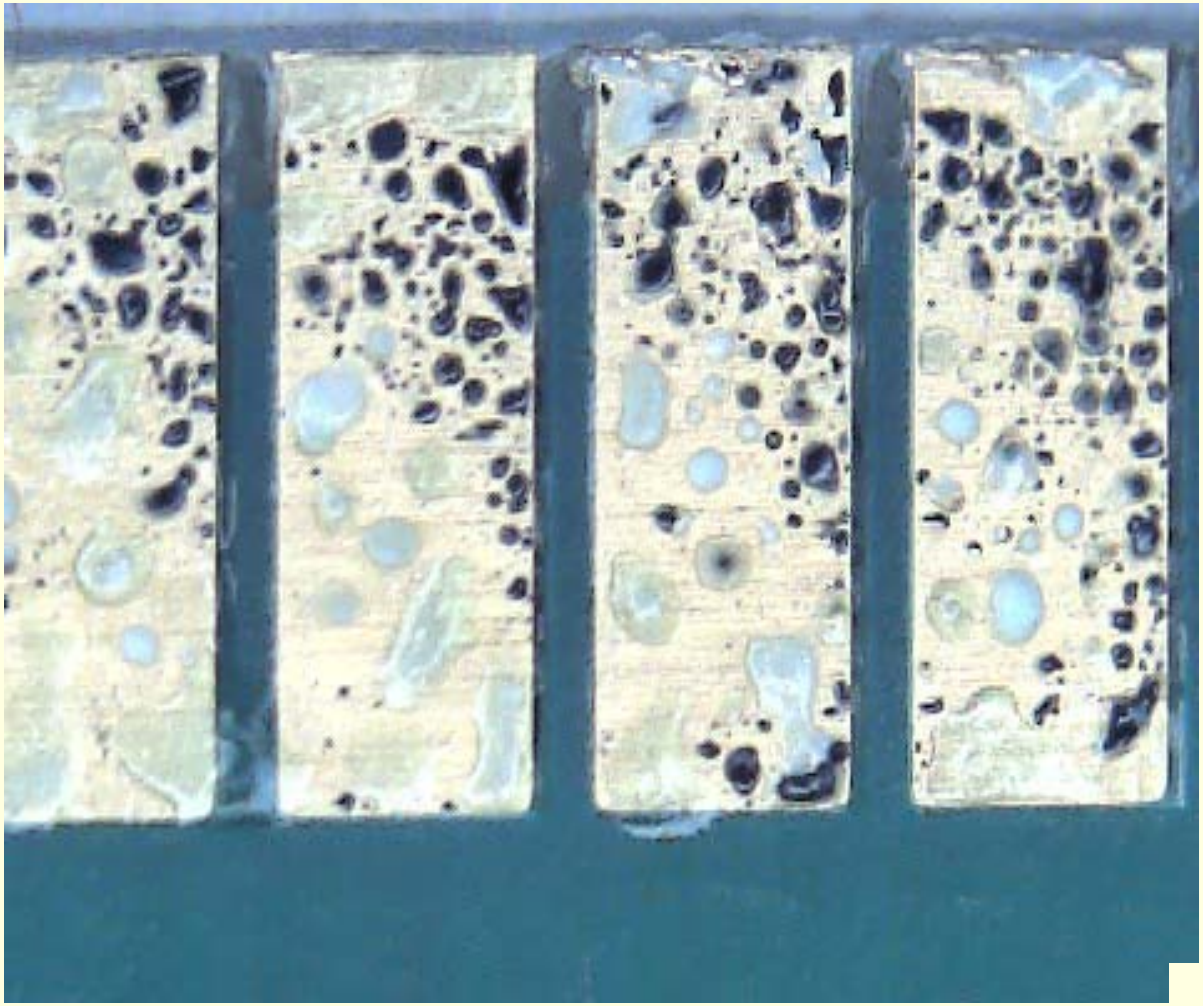
Procedure

- Ultrasonic clean samples with acetone
- Place in Desiccator
- 10 ppm SO_2
- 24 hours
- 42°c

Criteria

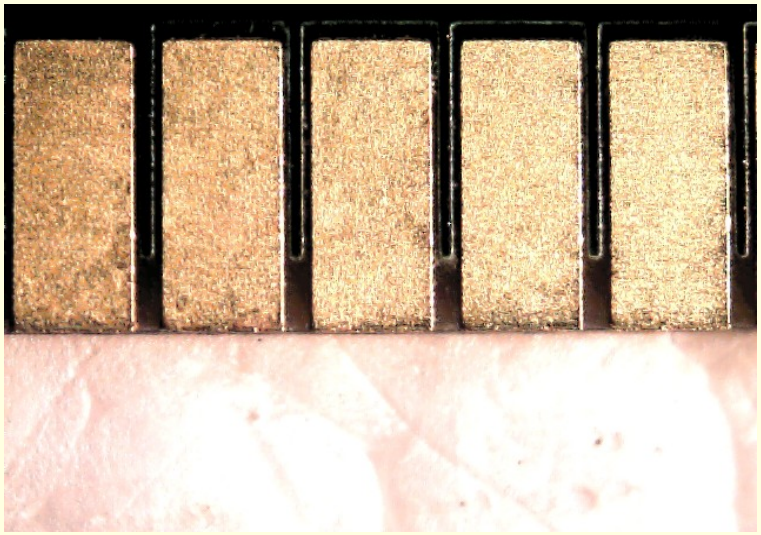
- Corrosion hole diameter (mm)
  - >0.4 1
  - 0.12 to O.4 <15
  - 0.05 to 0.12 -
  - Total corrosions <30

Failure After 24 hr SO^2 Test

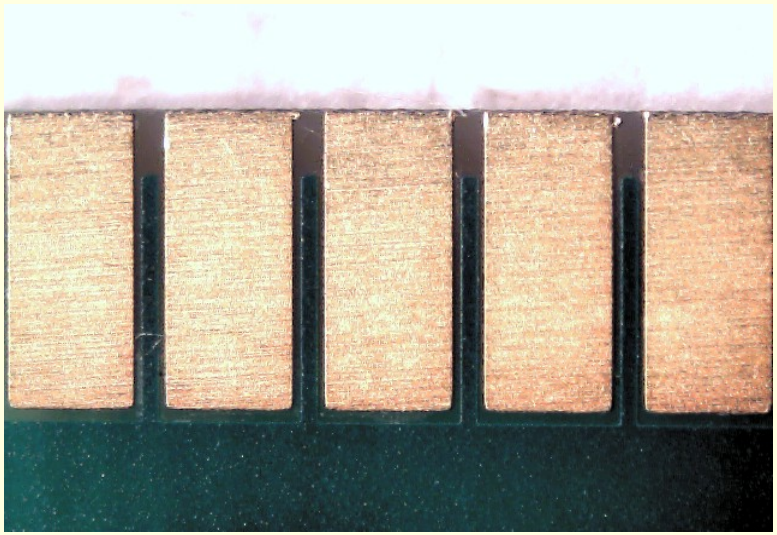


24 Hour SO_2 Corrosion Test Results

0 MTO

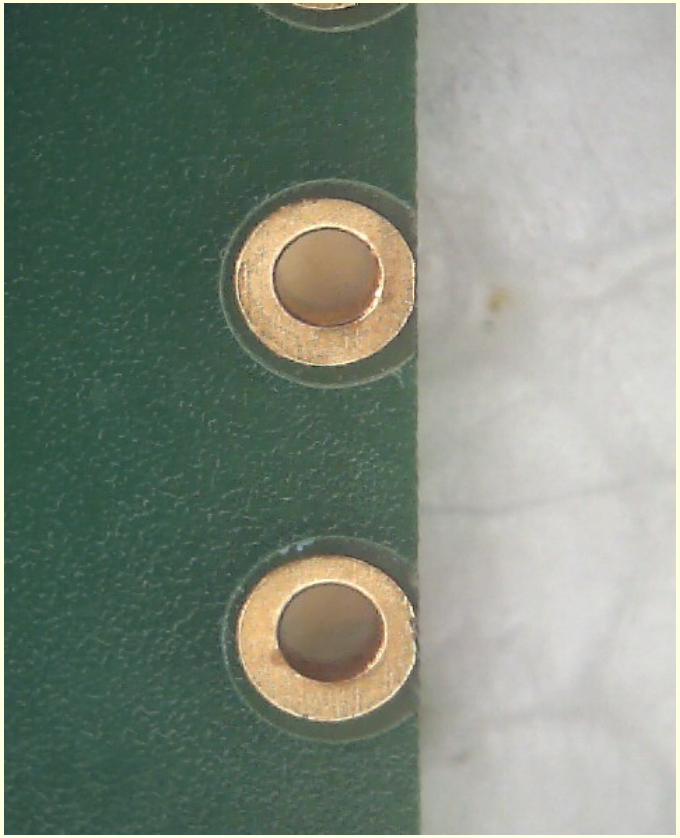


5 MTO

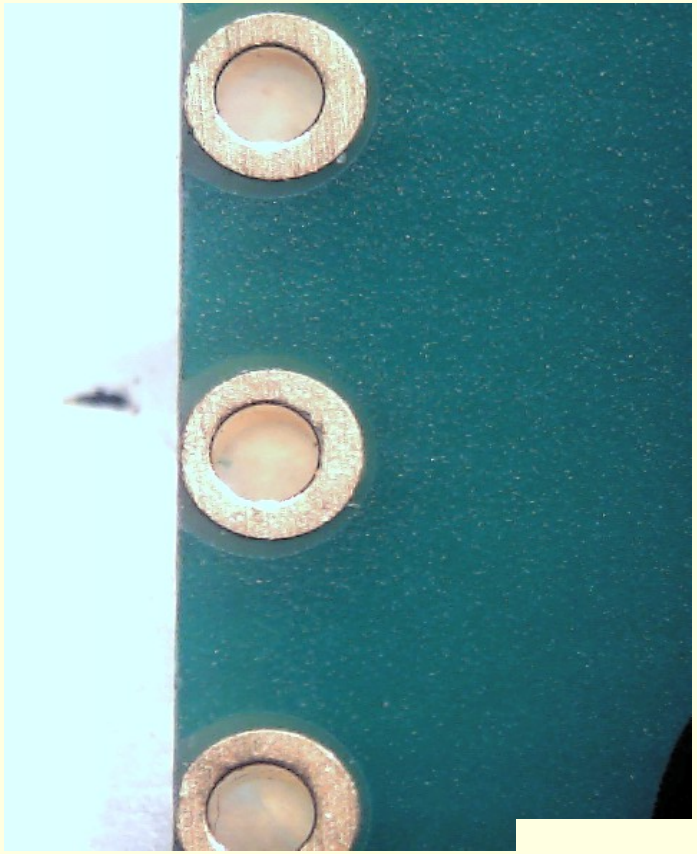


Land Areas After 24-hour SO_2 Test & Tape Test

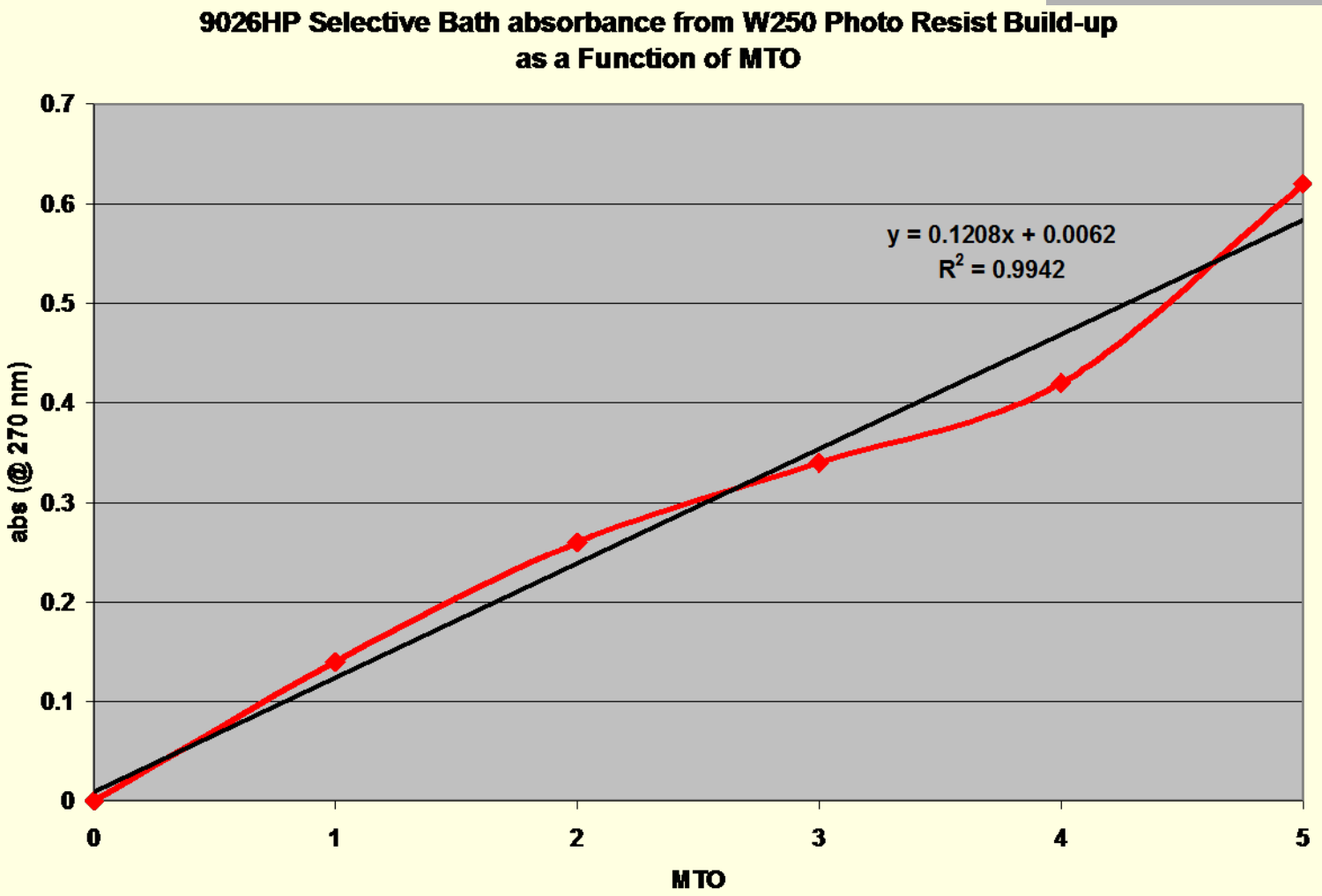
0 MTO



5 MTO

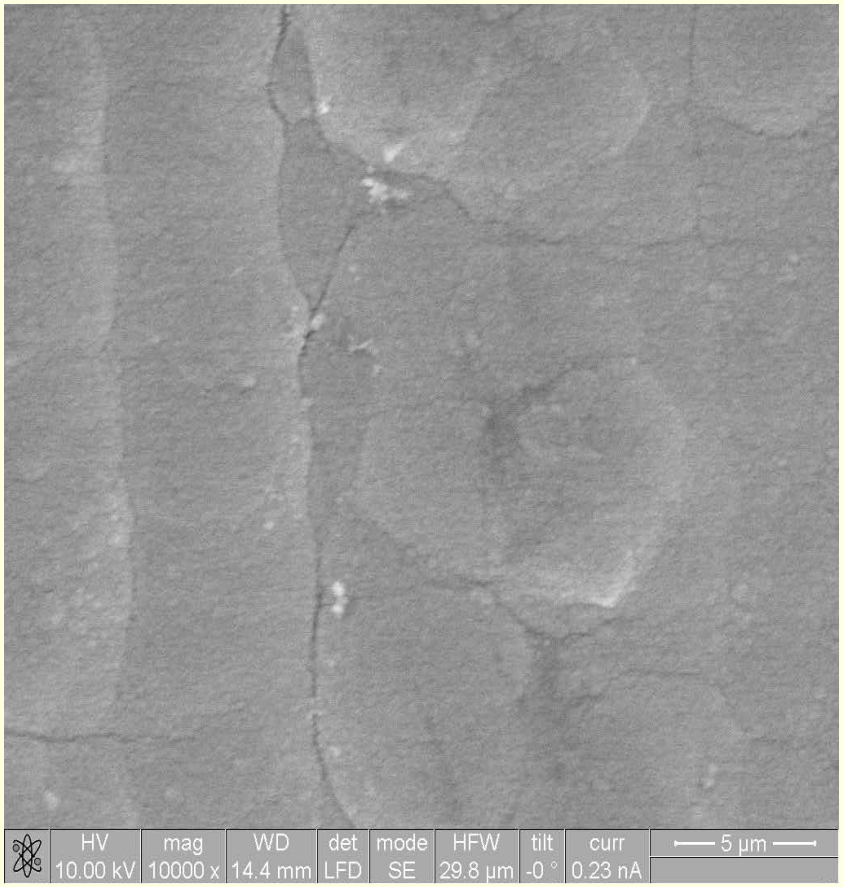


Absorbance Levels vs Nickel MTO's

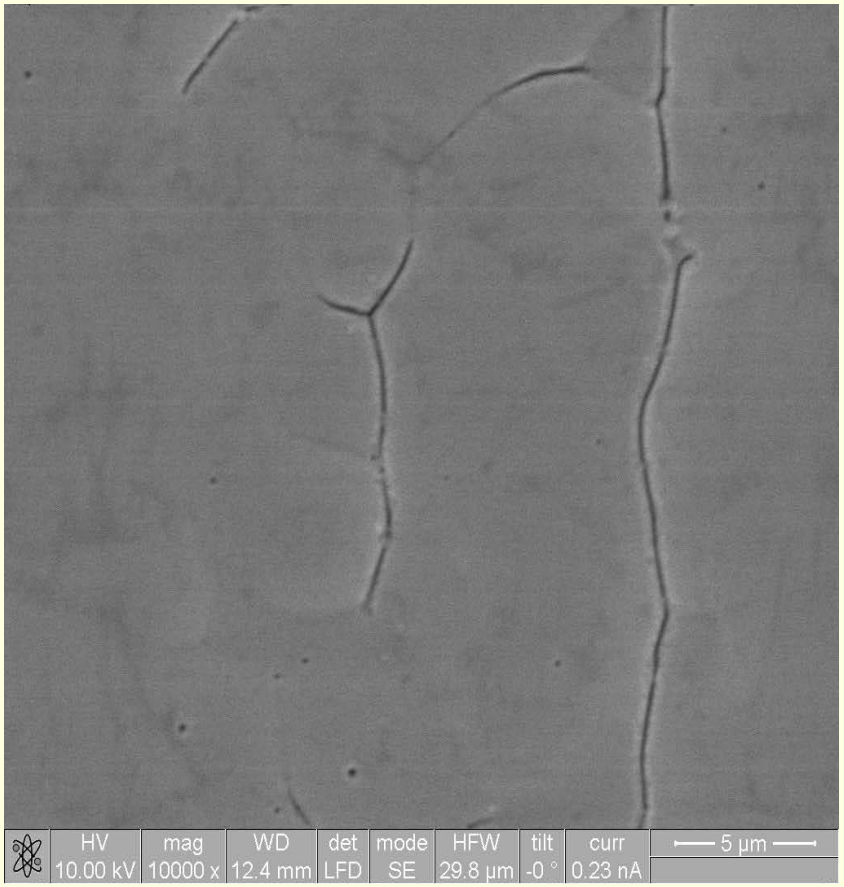


Surface Morphology After 3 OSP Cycles

0 MTO

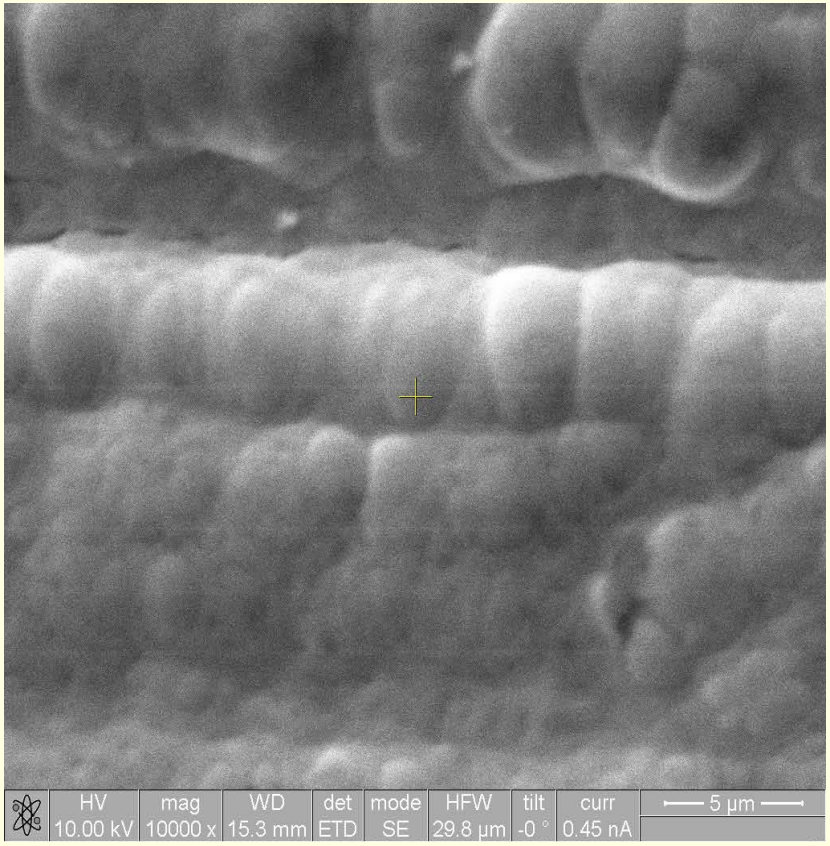


1 MTO

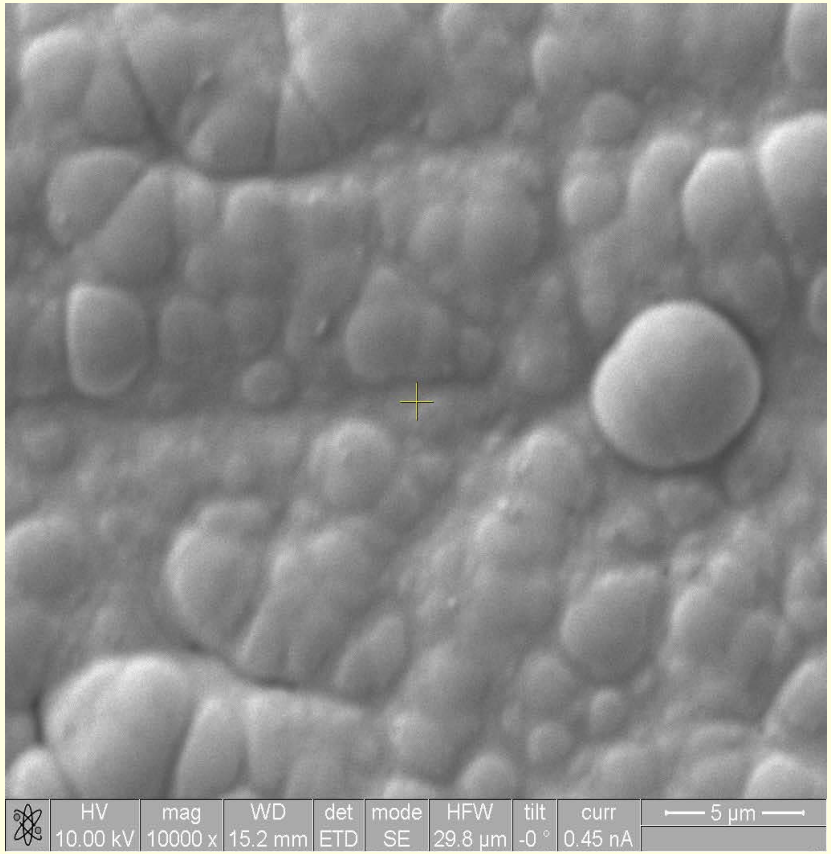


Surface Morphology After 3 OSP Cycles

4 MTO



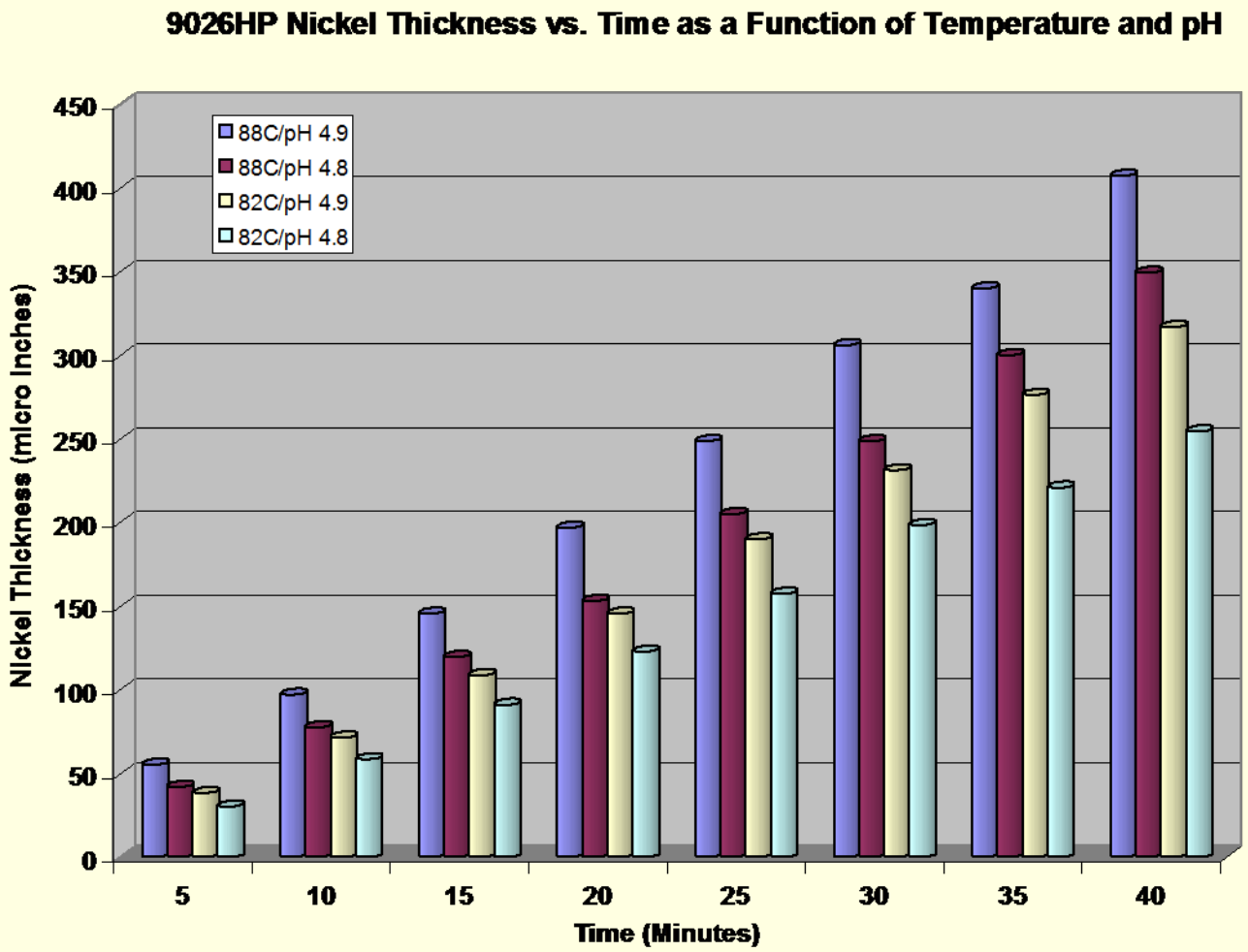
5 MTO



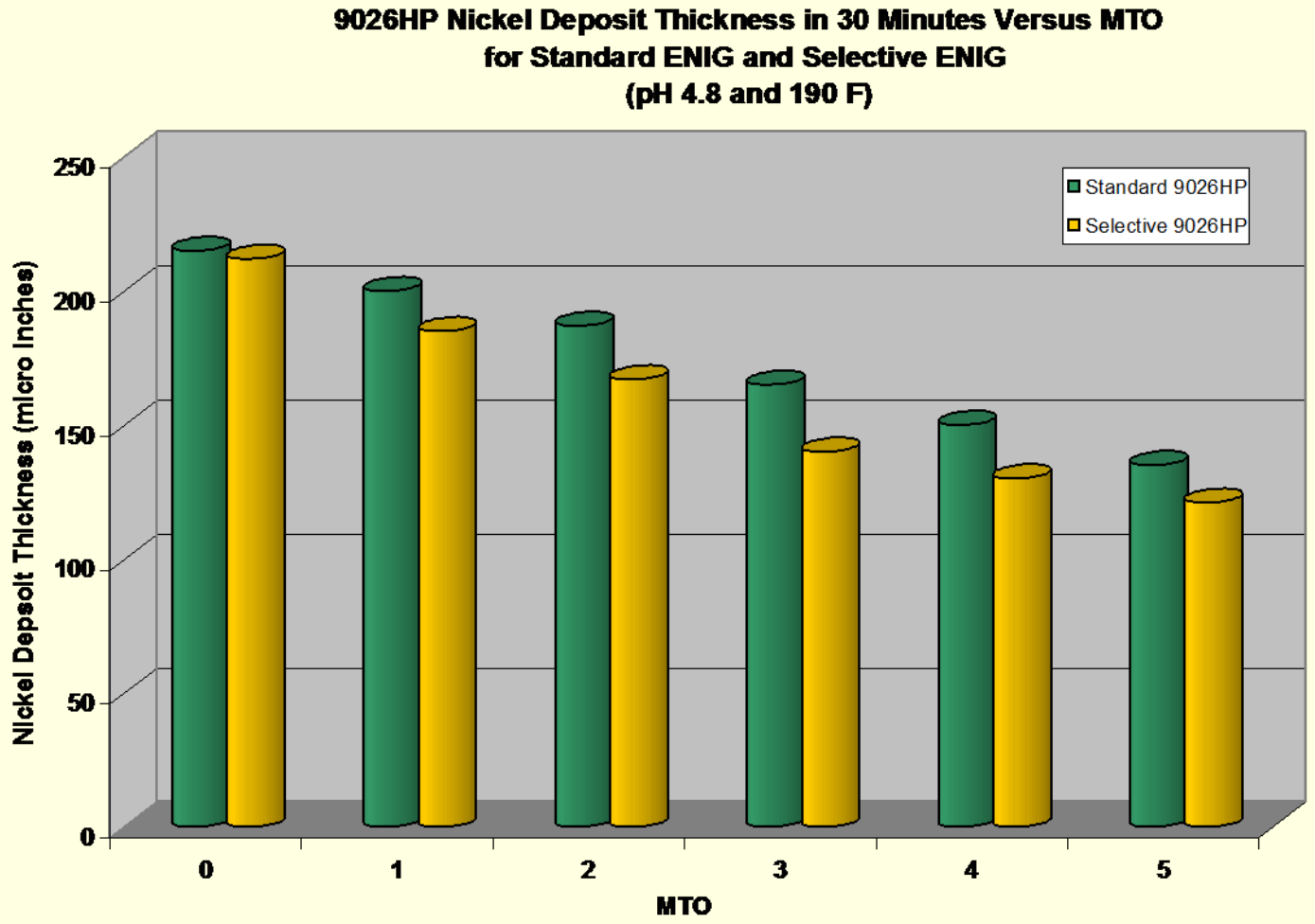
Effect of Operating Parameters on OSP Cycles

Parameter	Level Of Effect (As Parameter Increases)
EN Bath Temperature	+
EN Bath pH	+ +
EN Deposit Thickness	++
% Phosphorous in EN Deposit	+++
Immersion Gold Bath Temperature	+ +
Immersion GOLD Bath pH	0
Immersion Gold Concentration	_ _
Immersion Gold Deposit Thickness	+ +

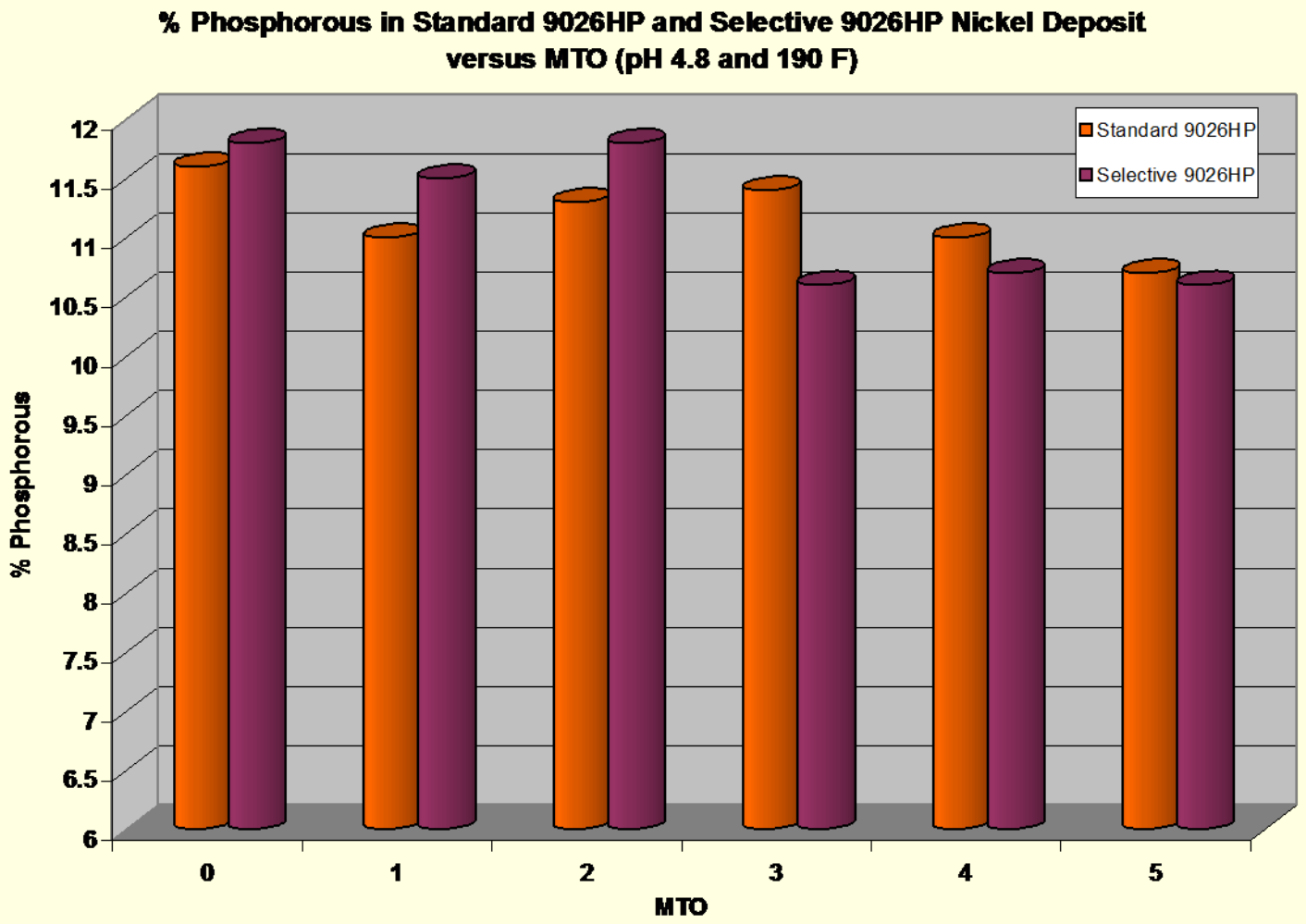
Nickel Thickness vs Time/Temp/pH



Nickel Thickness Standard vs SENIG



Phos Levels vs MTO's



Gold Thickness vs Nickel MTO's