



By Berl Stein, CEF

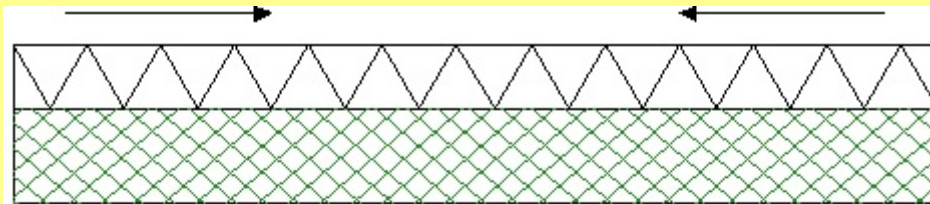
Practical Stress Control in Electroforming

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Presentations

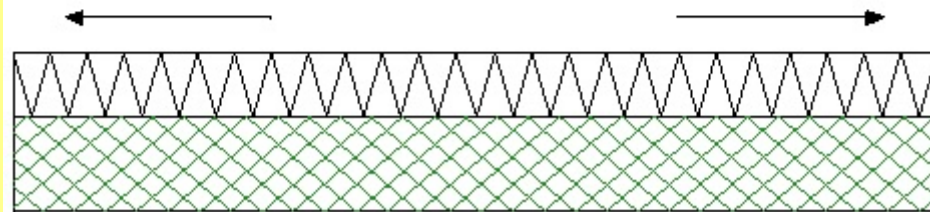


The Nature of Things

(Definitions)



Deposit Stressed in tension (expanded spring) is “trying” to contract relative to the substrate



Compressively Stressed Deposit (contracted spring) is “trying” to expand relative to the substrate

STRESS (Noun) :

The act, condition, or effect of exerting force on someone or something
(*Roget's Electronic Thesaurus*)

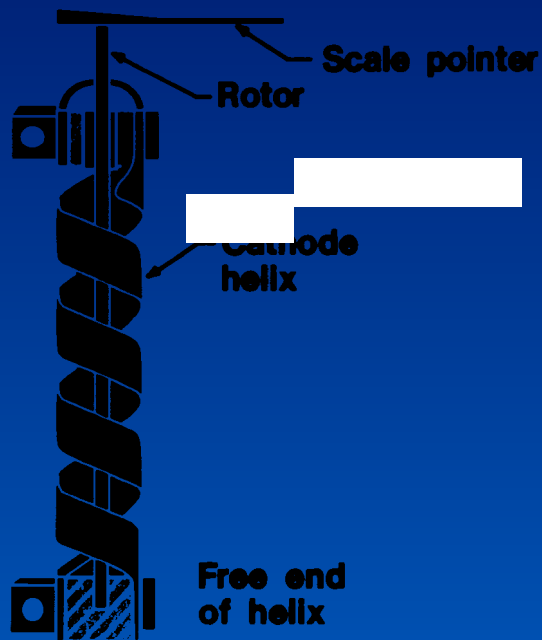
Stress-Related Electroforming Problems

(A very condensed list)

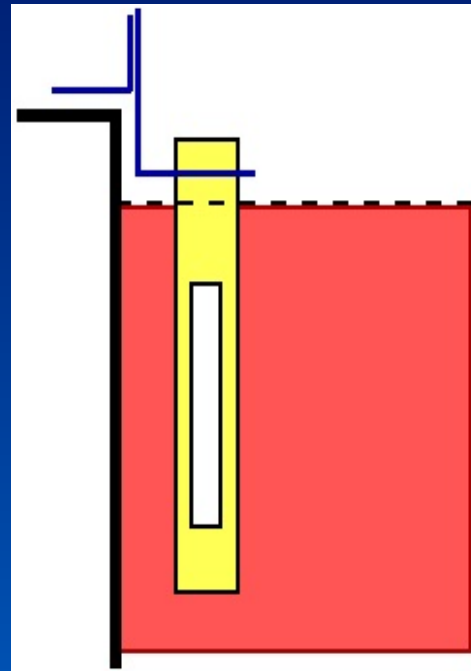
- Loss of reproduction fidelity
- Electroform distortion (warping, deformation, etc.)
- Premature form/mandrel separation resulting in the loss of mandrel and form
- Form oversized or undersized resulting in mandrel separation difficulty
- In extreme cases - loss of electroform integrity (cracking)

Manual Techniques for Measuring Internal Stress

Quantifying the problem



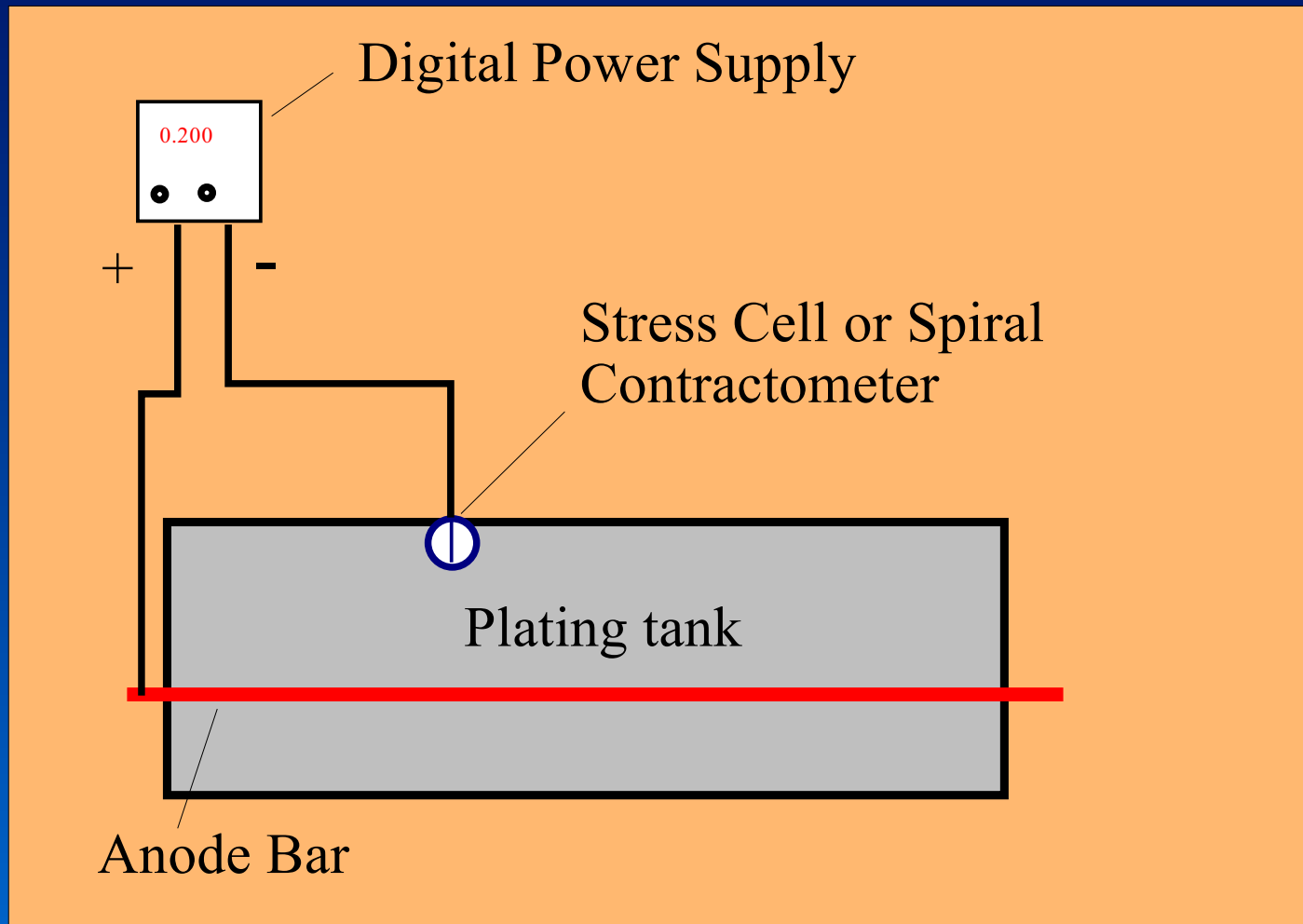
1. Spiral Contractometer



2. In-Tank Stress Cell and Bent Strip on Stand



In-Tank Stress Measurement Schematic

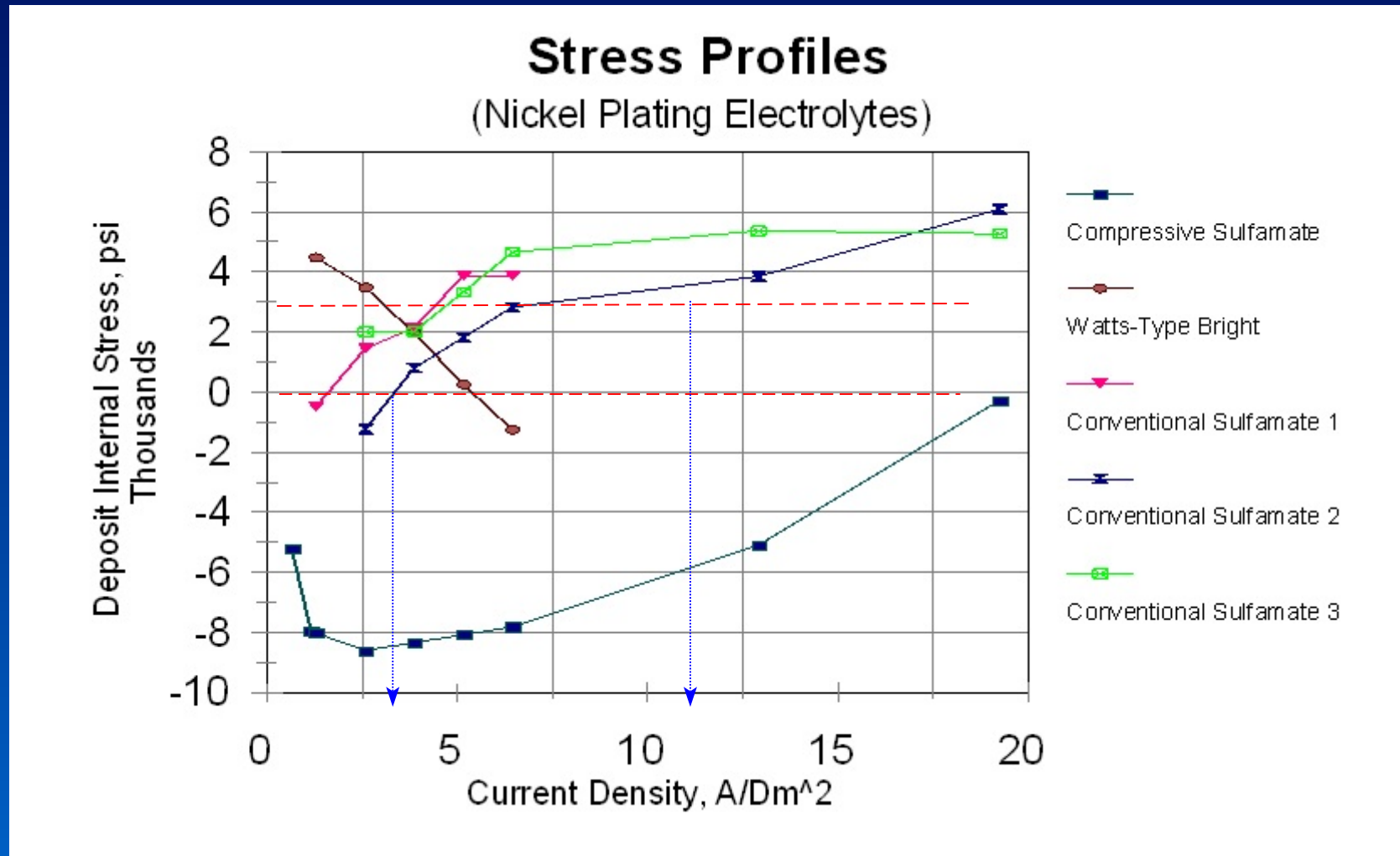


Bent Strip and Spiral Contractometer Comparison

Parameter	Bent Strip	Spiral Contractometer
Resolution (4 μ m/.00015 in deposit)	~10 Mpa*	~55 Mpa
Resolution (8 μ m deposit)	~2 Mpa	~14 Mpa
Resolution (16 μ m deposit)	- - -	~4 Mpa
Typical Setup Time	5 min	25 min
Typical Test Duration	~20 min	~60 min
Maximum Test Frequency	2 per hour	1 per day per available helix
Substrate cost	\$3.00 ea.	\$75.00 ea. (reusable)
Ability to Use Different Substrates	No	Yes, with purchase of add-l heli
Cost of Measuring System	<\$250	\$1000 (\$2000 w/ ext. Anode)

*Conversion: 1 Mpa = 145 psi

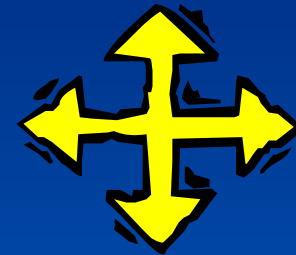
Stress Profiles and Process Windows



Some Factors Affecting Deposit Internal Stress

(A partial list)

- Current density
- Concentration of most plating bath components (metal salts, conductive salts, buffering agents, wetters, etc.)
- Concentration of additives (organic or inorganic)
- Concentration of impurities (chemical and particulate)
- Bath temperature
- Agitation rate and direction of flow
- Solution pH
- Plating cell geometry (relative position/size of parts/anodes, shields, robbers)
- Composition and condition of anodes
- Anode/cathode surface area ratio
- Quality of DC power (ripple)



Practical Ways of Controlling Internal Stress in the Deposit



- Current density adjustment. Used primarily in automatic systems with a real-time stress monitoring device.
- Temperature adjustment. Can be used in the same mode as above
- Organic additives. Can be used in manual or automatic modes
- Ni-Speed system with S-free ('passive') auxiliary anodes
- Periodic Reverse or Pulse Plating

Some Useful Papers

On Deposit Stress Measurement and Control

- G. G. Stoney, *Proceedings of the Royal Society*, A82: 172, 1909
- A. Brenner and S. Senderoff, *Proc. Amer. Electroplaters' Soc.*, 35,53, 1948
- B. Stein, *A Practical Guide to Understanding, Measuring and Controlling Stress in Electroformed Metals*. AESF Electroforming Symposium, March 27-29, 1996, Las Vegas, NV
- G. Richardson and B. Stein, *Comparative Study of Three Internal Stress Measurement Methods*. AESF Electroforming Symposium, October 1-3, 1997 Sand-Diego, CA

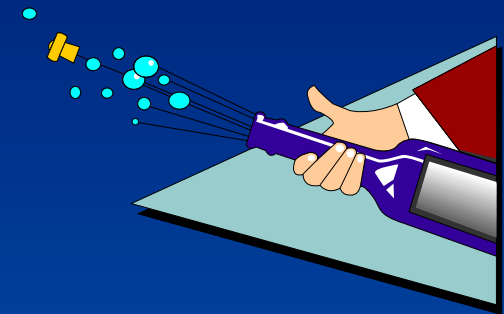
Stress Control Summary

(Not a Recipe but Close)

1. Settle on a stress measurement technique
2. Study your chemistry and define variable(s) with a strong influence on deposit stress
3. Choose one control variable (the one you will be changing) and stabilize the rest
4. Decide on the frequency of testing and adjustments to the control variable
5. Implement the system and observe results
6. If unsatisfactory, go back to steps 1 or 2 and repeat all steps until happy with the result. If satisfactory, go to the next slide.



Stress is Eliminated



Sweet Victory