bore, no tension is developed until the initial induced compressive stress is overcome. This technique can be extended to 3 or more cylinders; however, the advantage gained becomes less with each additional ring.

Interference ring assemblies can be fitted either thermally or mechanically. Straight wall cylinders are used in the thermal method and fitting is generally carried out at the maximum permissible temperature differential. Slightly tapered cylinders are used in mechanical assembly with the interference force generally applied by a hydraulic press. Careful machine practices should be observed in fabricating all mating surfaces.

If the pressure induced by the interference fit is known, equations (1) through (4) above can be used to analyze initial stresses in the cylinder assembly. The magnitude of induced pressure can be determined from the radial strains required to assemble the rings. For the assembly of materials with identical elastic constants the pressure is given by (9)

$$p = \frac{E\delta}{b} \frac{(b^2-a^2)}{2b^2} \frac{(c^2-b^2)}{(c^2-a^2)} \qquad (5)$$

where p = contact pressure
E = modulus of elasticity
δ = the amount of interference
a,b,c = the internal, contact and external radii, respectively, of the compound cylinder.

Should the components of the cylinder assembly have different elastic constants, the equation must be modified. For a carbide inner cylinder and steel jacket, we have

$$p = b \quad \frac{c^2+b^2}{c^2-b^2} + \overset{\delta}{\frac{b^2+a^2}{b^2-a^2}} + \frac{\alpha \mu \mu}{\alpha} \qquad (6)$$

where E_s = modulus of elasticity of steel
E_c = modulus of elasticity of carbide
μ = poisson's ratio for steel
μ = poisson's ratio for carbide
$\alpha = \frac{E_c}{E_s}$

Because of the presence of unavoidable shear gradients at the piston - pressure media boundary which may cause a lateral failure of the inner cylinders at very high pressure, a strong support force against the end faces of the inner cylinders is desirable. Heavy steel plates drawn up with high strength bolts are generally effective for this purpose. As a precaution against cylinder failure it has been found to be prudent to provide a mild steel safety ring around the compound cylinder assembly.

The Potential of High Pressure - High Temperature Research with Respect to Electronic Applications

There are two principle catagories by which research at elevated pressures and temperatures can contribute to electronics. The first and most important is the extension of knowledge and understanding of the properties of matter. Although this field of investigation is still in its infancy, a remarkable amount of preliminary work already has been done. Research has been reported (1) on the effect of pressure on the dielectric properties of various materials, index of refraction, optical absorption, magnetic permeability, crystal structure transitions, electronic transitions, electrical and thermal conductivity, melting phenomena, thermoelectric power and electromotive force, viscosity, surface compressibility, general strength of materials, wave transmission, reaction rates, radioactive disintegration, and condensed crystal structures. In some cases, theoretical explanations have been developed.

The second category is of a more practical nature with a promising potential to practical electronic application. Essentially, it deals with the synthesis of stable or metastable forms of new materials or phases of existing materials.

Quantitatively, energy put into a system through the application of pressure can be described by the equation

$$\int P \, dV \equiv V_o \int P \, d \; {}^{\Delta}\overset{V}{V_o}.$$

and heat energy injected into a system can be expressed by

$$E_h = \int C \, dT + \sum \Delta E_{latent}$$

Roughly, one degree of temperature has the equivalency of one thousand atmospheres of pressure. Whereas pressure tends to bring matter together and suppress activity, however, increased temperature tends to separate and activate. At first glance, therefore, a combination of elevated pressures and temperatures would appear to be self-opposed with respect to inducing change into a given system. Use of proper timing sequence in applying and combining these two antagonostic forms of energy, however, has been found to be highly effective in overcoming reaction barriers, stimulating reaction rates and inducing metastability in otherwise unstable systems. The sequence consists of pressure application, temperature application, reduction of temperature, reduction of pressure.

At present, the formation of diamond by the General Electric Company is the most dramatic example of elevated pressure-temperature systhesis. Borazon is another. (10) Both possess potential applications as semi-conductors of high thermal, chemical and physical stability. Other materials of similar interest are cubic SiC and some aluminum boride phases. First, however, instrumental capabilities must be developed that will permit the growth of crystals of sufficient size, and chemical and structural perfection.

Other classes of materials that show promise for pressure-temperature synthesis are luminescent compounds such as AlN, AlP, GaP, ZnS and CdS; high energy metallic, covalent and glass compounds of superior radiation resistance, and solid state power source materials such as alpha AgI and transitional element compounds.

Compounds that possess elements which have unfilled inner electronic orbitals show special promise since it has been shown that very high pressures can affect the stability sequence of these orbitals. Such effects can be readily detected by marked changes in electrical conductivity. Cesium and cerium are two examples of this type of behavior. In all, there are over 60 elements that possess unfilled inner orbitals. The possibility exists that at sufficient pressure, outer electrons can be forced into inner positions thereby changing the normal chemical and physical behavior of these elements. Some research workers have taken the view that the possibility exists that a "new" periodic table may be created in the future. (11)

Another possibility of promise to electronics is the possible synthesis of a metallic phase of ammonia. Theoretically, pressures of approximately 2×10^5 atmospheres (12) will be required. The conversion of hydrogen to a metallic phase would be theoretically possible at pressures of the order of 2×10^6 to 9×10^6 atmospheres according to the most recent calculations. (13) Although instrumentation is on the threshold of capability for work on ammonia, most likely, any serious consideration of work that requires pressures of millions of atmospheres must await the development of new philosophies on instrument design. The use of pulsed magnetic fields (7) may offer one possibility.

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