Guest Editorial

Metal Optics

James C. Wyant
Optical Sciences Center, University of Arizona
Tucson, Arizona 85721

Although all the early telescope mirrors were made of speculum metal, once the chemical process for metallizing a glass surface became known in about 1850, glass replaced metal as the most common substrate material. However, there are now new applications, such as in the high energy laser field, where the high damage threshold and potential lower fabrication costs make the use of metal mirror substrates appealing. These new applications, coupled with recently developed diamond-turning fabrication techniques, have, during the past five years, made the field of metal optics extremely interesting, and the potential developments for the next five or ten years are even more exciting. The purpose of this special issue on "Metal Optics" is to summarize the reasons for the revival of the use of metal substrates. The issue describes the basic properties of metal mirrors and the most modern fabrication and testing techniques, as well as some of the applications.

The first paper, by W. P. Barnes, Jr., describes the basic properties of metals pertinent to their use as a mirror substrate. Specularity, surface figure, dimensional stability and environmental stability are discussed. The conclusion is reached that metals offer advantage in environments where heat flux is of major importance, as well as in other applications where the conveniences of forming, shaping, drilling and tapping of metals are important.

The second paper, by J. B. Arnold, T. O. Morris, R. E. Sladky, and P. J. Steger describes the use of diamond-turning techniques for the fabrication of optical components. It is probably this application of diamond turning, previously developed for ultraprecision turning of machine parts, that is responsible for the large present-day interest in metal optics. Studies are also being performed to study the application of the diamond-turning techniques to the fabrication of infrared windows.

While diamond-turning techniques are useful in the fabrication of metal optics, traditional lapping and polishing techniques are still very important. The paper by R. E. Parks, R. E. Sumner, and J. T. Appels describes some differences between the polishing of metals and the polishing of glass. The paper by R. A. Hoffman and W. J. Lange describes another method of polishing a metal surface, namely ion polishing. The results given in the paper show that a combination of ion polishing and vacuum annealing can be used to greatly reduce the optical absorptance of 10.6 μm radiation by conventionally polished copper mirrors to a value as low as that for micromachined mirrors.

Part of the reason for the large interest in metal mirrors is that diamond-turning techniques make it possible to fabricate some of the nonconventional shaped optics required for high-energy laser systems. The next two papers describe the fabrication of optics which could not be economically produced using conventional techniques. The first paper, by J. B. Arnold, T. T. Saito, R. E. Sladky, P. J. Steger and N. D. Woodall, describes some of the fabrication and testing techniques available for producing axicons, waxicons, torics and multifacet mirrors. The second paper, by D. N. Mansell and T. T. Saito, describes the theory, design and fabrication of a nonlinear waxicon.

Just as for the fabrication of glass optics, the proper fabrication of metal optics depends upon the testing techniques available. A surface characteristic of particular interest to many high energy laser systems is scattering. The paper by E. L. Church, H. A. Jenkinson and J. M. Zavada describes the measurement of scattered light off a diamond-turned metal surface. The paper shows that the scattering spectra produced by a diamond-turned surface can be separated into three groups corresponding to three classes of surface roughness: periodic tool marks and one- and two-dimensional random roughness.

The paper by R. N. Shagam, R. E. Sladky and J. C. Wyant describes the measurement of the overall figure of diamond-turned optics. Due to surface ripple, conventional slope measurement techniques such as the Foucault test cannot be used. As illustrated in the paper, conventional interferometry can be used if certain precautions are taken.

The last two papers deal with applications of metal optics. The paper by W. H. Reichelt, D. J. Blevins and W. C. Turner describes the use of metal optics in CO_2 laser fusion systems. These fusion systems are relying very heavily on the use of diamond-turned metal mirrors, both because of their good operating properties and their cost-and-time-effective means of production. As described in the last paper by F. E. Johnson and T. T. Saito, diamond-turned optics have applications in other infrared optical systems. Not only does the fabrication process promise significant cost savings as compared to conventional lapping and polishing methods, but a broader usage of diamond-turned aspherics can reduce the number of components required. Thus, although there are still many problems involved in the fabrication of metal optics which need to be solved, the future of metal optics does indeed look exciting.