

**DEVELOPMENT AND APPLICATION OF A NOVEL  
OPTICAL TEMPERATURE/HEAT FLUX SENSOR FOR  
ADVANCED BLADE COOLING RESEARCH AND  
ENGINE THERMAL DIAGNOSTICS**

September 1, 1994 to August 31, 1997  
Final Report

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## EXECUTIVE SUMMARY

AGTSR FINAL REPORT  
Department of Mechanical Engineering  
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Pittsburgh, PA 15213

Project Title: Development and Application of a Novel Optical Temperature/Heat Flux Sensor for Advanced Blade Cooling Research and Engine Thermal Diagnostics

AGTSR Subcontract No.: DE-FC21-92MC29061

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### Executive Summary

The primary objective of this AGTSR project is to develop the thermographic phosphor (TGP) based imaging technology for gas turbine heat transfer applications. The project has been completed on schedule and fulfilled the proposed research plan. The major accomplishments include:

- (a) establishment of a laser-induced, TGP fluorescence imaging system,
- (b) design, fabrication and demonstration of an optical heat flux sensor based on TGP,
- (c) acquisition and calibration of high temperature phosphors,
- (d) fabrication and heat transfer measurement over an ATS airfoil in a transient cascade tunnel.
- (e) TGP applications to discrete-hole film cooling,
- (f) analyses of three- and four-temperature film cooling problems, and
- (g) TGP applications to film cooling with gap leakage on turbine endwalls.

Overall, the TGP fluorescence imaging has been demonstrated as one of the most effective means for measurements of surface temperature and heat transfer. While discrete-point surface temperature using TGP has been reported previously, the present study marks the first attempt and success in revealing the full surface mapping of temperature as well as local heat transfer coefficient. The latter aspect is particularly significant, since determination of local surface heat flux over a turbine component is generally difficult.

As a somewhat unexpected finding, the TGP technology is particularly effective in characterizing the performance of film cooling with multiple driving temperatures. Its unique feature in resolving film effectiveness and local heat transfer coefficient simultaneously is unmatched by any other measurement approach for turbine cooling applications. Many complex while unresolved turbine heat transfer problems can now be tackled. It is anticipated that the knowledge gained from this research will not only further advance the TGP measurement technology that benefits the heat transfer community in general but will also provide the gas turbine industry with an effective way of thermal instrumentation.