

Part I
Advantages & Applications of Slab type YAG Laser
Part II
R & D Status of All Solid-State Laser in JAPAN

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November, 26, 1998

Summary

- Part I -

As market needs become more various, the production of smaller quantities of a wider variety of products becomes increasingly important. In addition, in order to meet demands for more efficient production, long-term unmanned factory operation is prevailing at a remarkable pace. Within this context, laser machines are gaining increasing popularity for use in applications such as cutting and welding metallic and ceramic materials. FANUC supplies four models of CO₂ laser oscillators with laser power ranging from 1.5kW to 6kW on an OEM basis to machine tool builders. However, FANUC has been requested to produce laser oscillators that allow more compact and lower-cost laser machines to be built.

To meet such demands, FANUC has developed six models of Slab type YAG laser oscillators with output power ranging from 150W to 2kW. These oscillators are designed mainly for cutting and welding sheet metals. The oscillator has an exceptionally superior laser beam quality compared to conventional YAG laser oscillators, thus providing significantly improved machining capability. In addition, the laser beam of the oscillator can be efficiently transmitted through quartz optical fibers, enabling laser machines to be simplified and made more compact.

This paper introduces the features of FANUC's developed Slab type YAG laser oscillators and their applications.

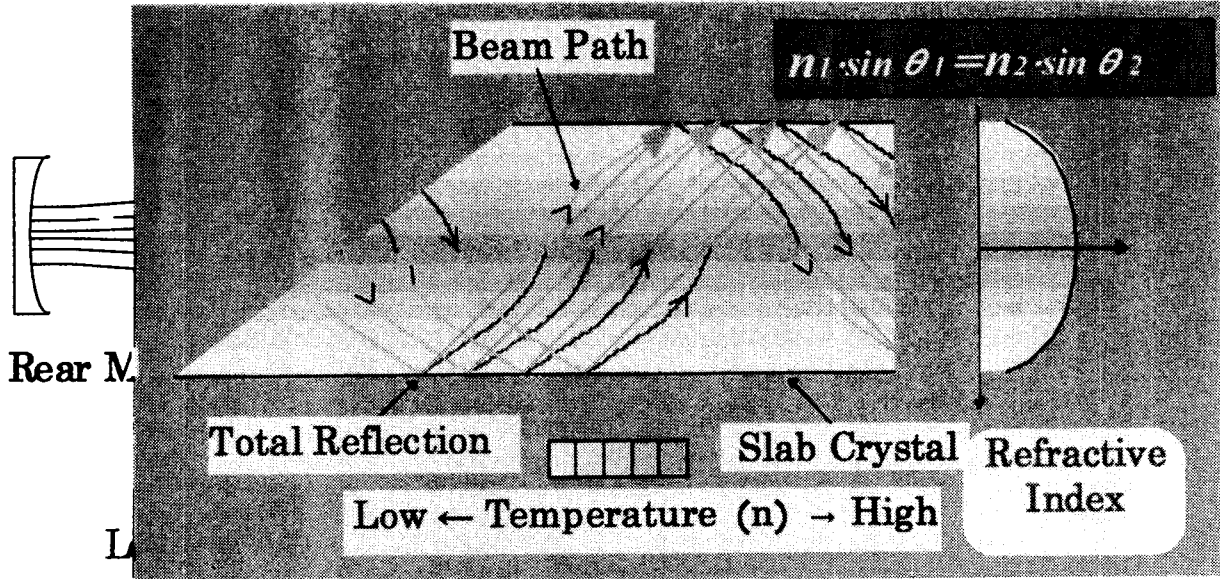
- Part II -

All-solid-state lasers employing laser diodes (LD) as a source of pumping solid-state laser feature high efficiency, compactness, and high reliability. Thus, they are expected to provide a new generation of processing tools in various fields, especially in automobile and aircraft industries where great hopes are being placed on laser welding technology for steel plates and aluminum materials for which a significant growth in demand is expected. Also, in power plants, it is hoped that reliability and safety will be improved by using the laser welding technology. As in the above, the advent of high-power all-solid-state lasers may not only bring a great technological innovation to existing industry, but also create new industry.

This is the background for this project, which has set its sights on the development of high-power, all-solid-state lasers with an average output of over 10kW, an oscillation efficiency of over 20%, and a laser head volume of below 0.05m³. FANUC Ltd. is responsible for the research and development of slab type lasers, and TOSHIBA Corp. for rod type lasers. By pumping slab type Nd: YAG crystal and by using quasi-continuous wave (QCW) type LD stacks, FANUC has already obtained an average output power of 1.7kW, an optical conversion efficiency of 42%, and an electro-optical conversion efficiency of 16%. These conversion efficiencies are the best results the world has ever seen in the field of high-power all-solid-state lasers. TOSHIBA Corp. has also obtained an output power of 1.2kW, an optical conversion efficiency of 30%, and an electro-optical conversion efficiency of 12%, by pumping the rod type Nd: YAG crystal by continuous wave (CW) type LD stacks. The laser power achieved by TOSHIBA Corp. is also a new world record in the field of rod type all-solid-state lasers.

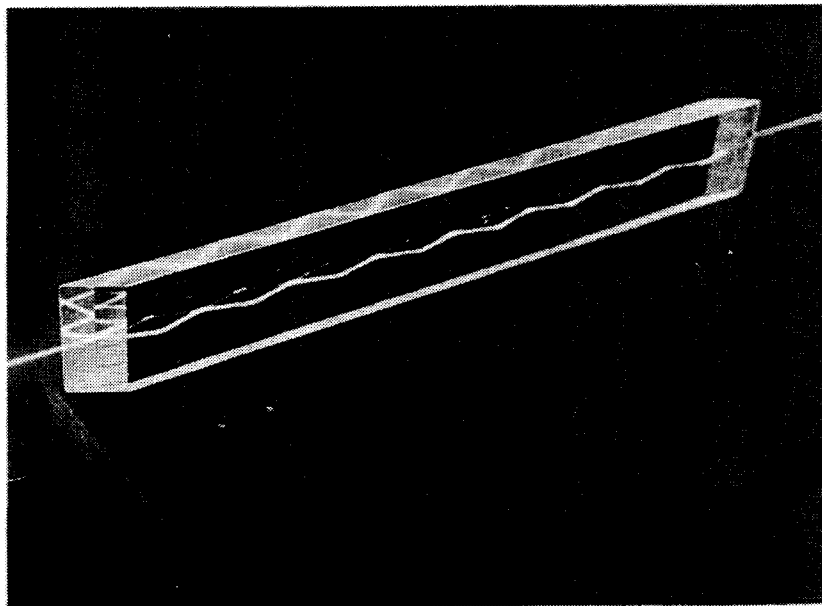
This report provides details of the above results and some information on future development plans.

Beam Propagation in a Crystal Rod vs Slab



FANUC Laser Optics

Slab Crystal



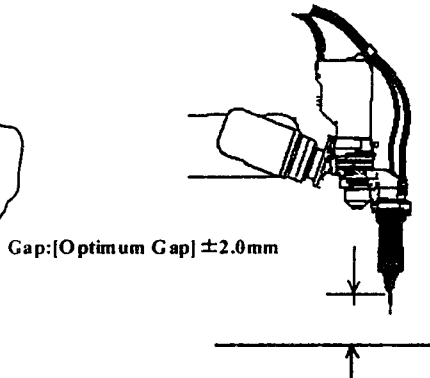
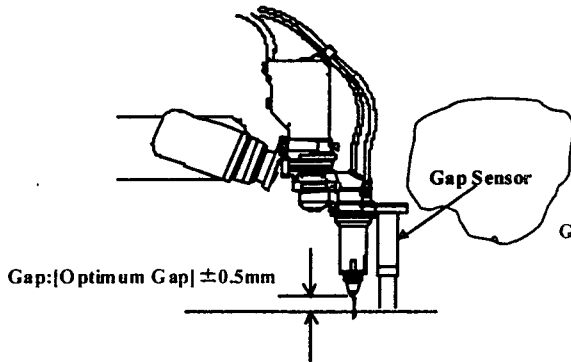
Zig-Zag Path

FANUC Laser Optics

Advantage of FANUC YAG Laser
- Fast & Accurate Processing -

Competitors

FANUC



- Sensor : Must
- Maintenance Period : Short
- Processing Speed : Low
- Processing Nozzle : Big

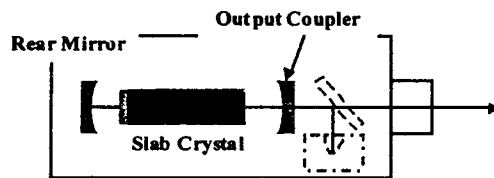
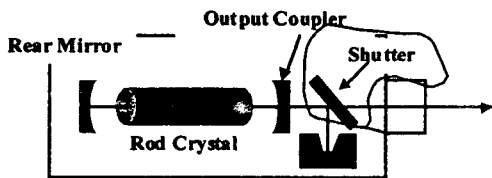
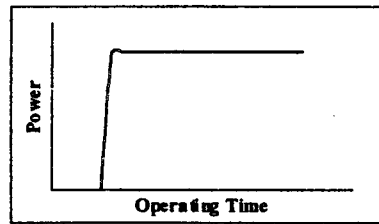
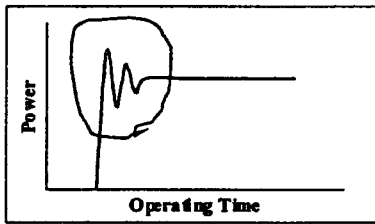
- Sensor : Non
- Maintenance Period : Long
- Processing Speed : High
- Processing Nozzle : Small

FANUC Laser lat

Advantage of FANUC YAG LASER
- Ecology -

Competitor

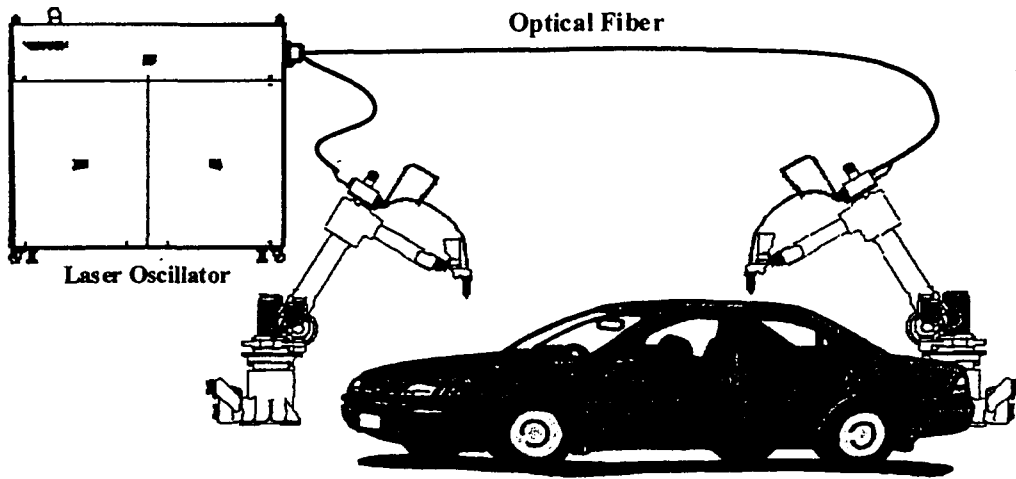
FANUC



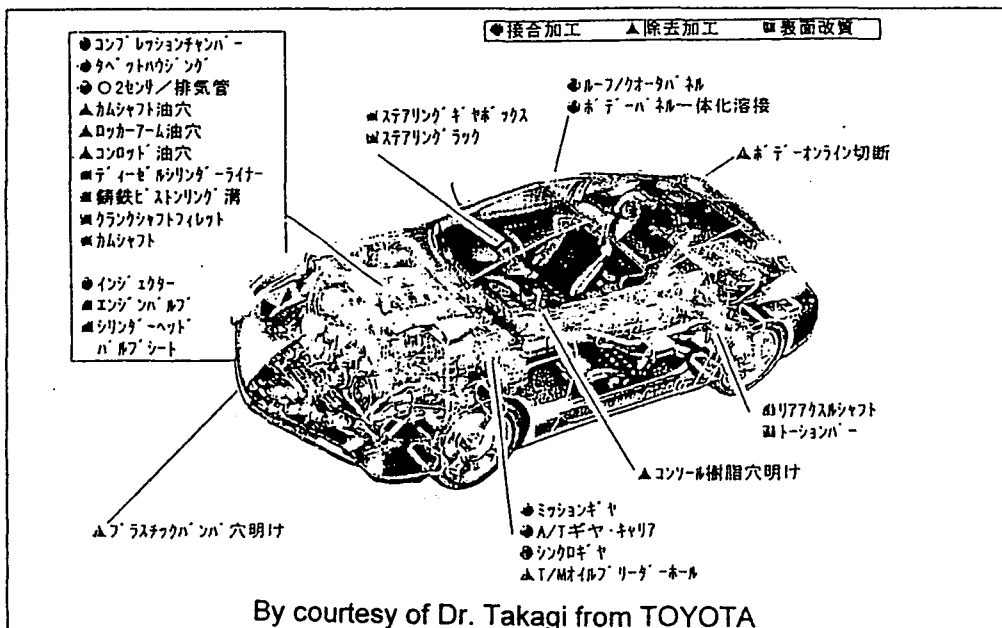
- Warming Up Time : Must (10-200sec)
- Lamp Life : Short
- Running Cost & Maintenance : High

- Warming Up Time : Non
- Lamp Life : Long
- Running Cost & Maintenance : Low

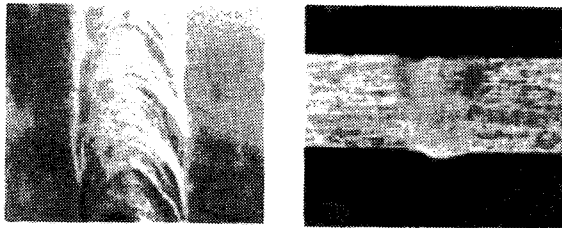
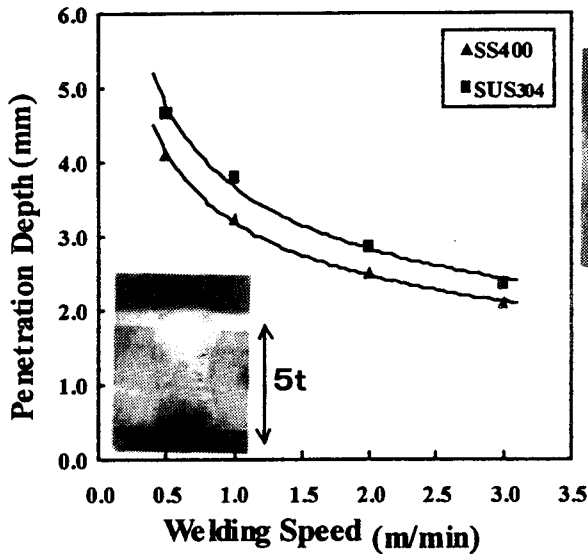
Applications of YAG Laser Robot System



FANUC LTD.

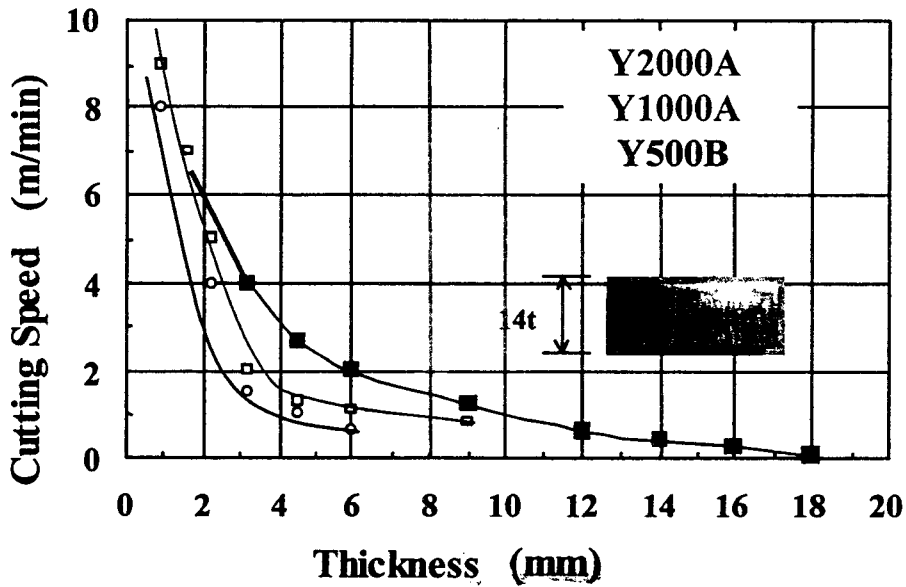


**FANUC YAG Laser -Y2000A-
-Welding Performances -**



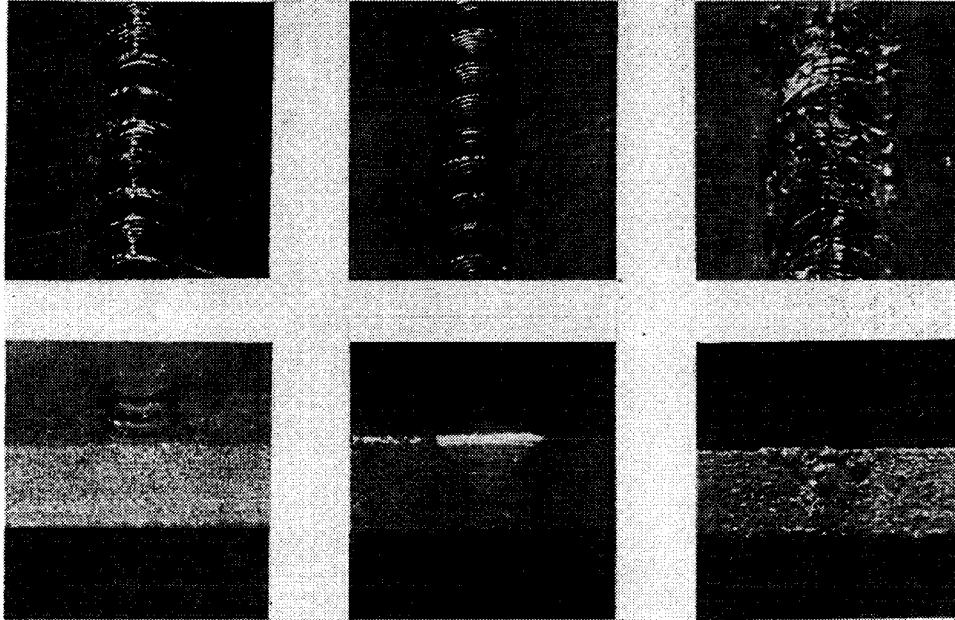
Aluminum(A5083)
Thickness : 3 t
Welding Speed : 1.0 m/min
Shielding Gas : Argon (10 ℓ/min)

**FANUC YAG Laser -Y2000A-
-Cutting Performances -**



Welding Performances of Aluminum

Condition: 1.0t, 2msec, 9J/p, 45pps, 0.9m/min



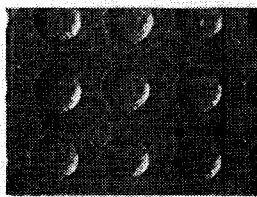
Al 1050

Al 3003

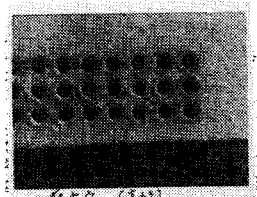
Al 5052

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Precision Processing of Ceramics



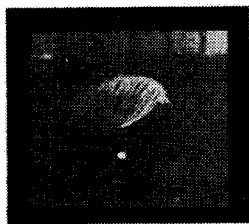
Dimpling



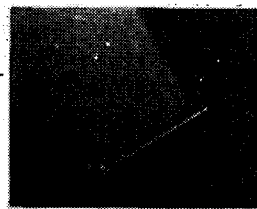
Drilling



Scribing



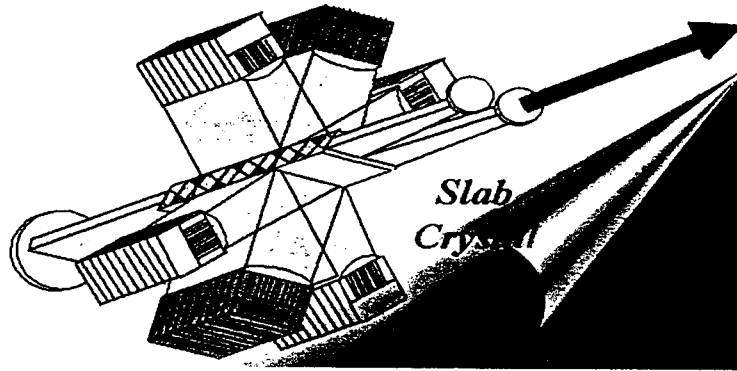
Cutting



3-D Processing

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“High-power/10kW/ All Solid-State Laser Technology”



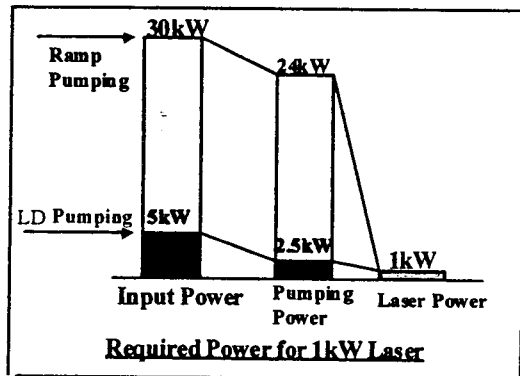
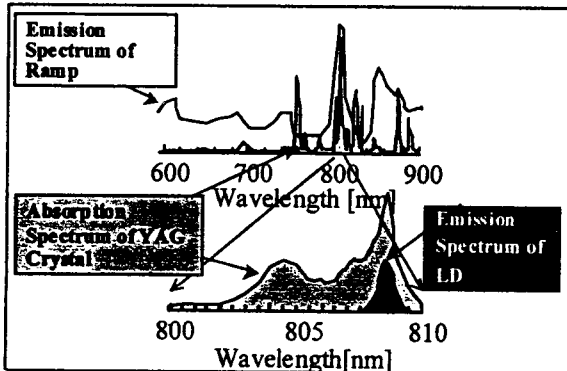
“Advanced Photon Processing and Measurement Technologies”



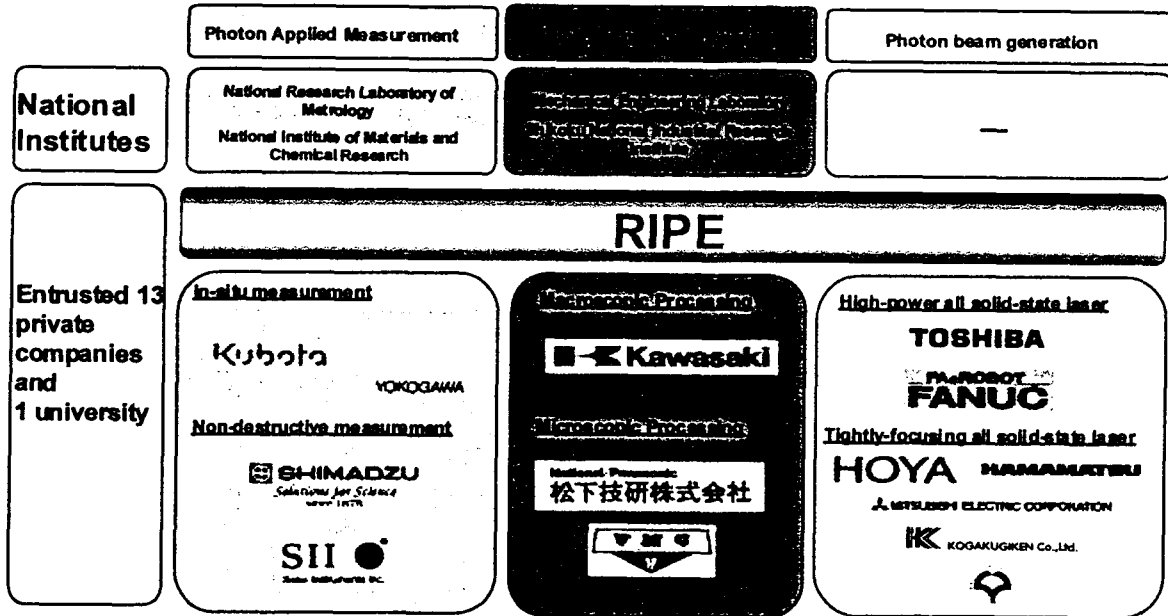
Advantage of LD pumping over RAMP pumping — High Efficiency · High Brightness · High reliability · Long Life —



- | | |
|--|---|
| •Low Efficiency / 3% | → High Efficiency / over 20% |
| •Low Brightness / Enormous Thermal Distortion in the crystal | → High Brightness / Low Thermal Distortion in the crystal |
| •Short Ramp Life / Below 500 h | → Long LD Life / Over 10000 h |
| •Low Reliability/ High Applied Voltage (1000V) | → High Reliability / Low Applied Voltage (5V) |

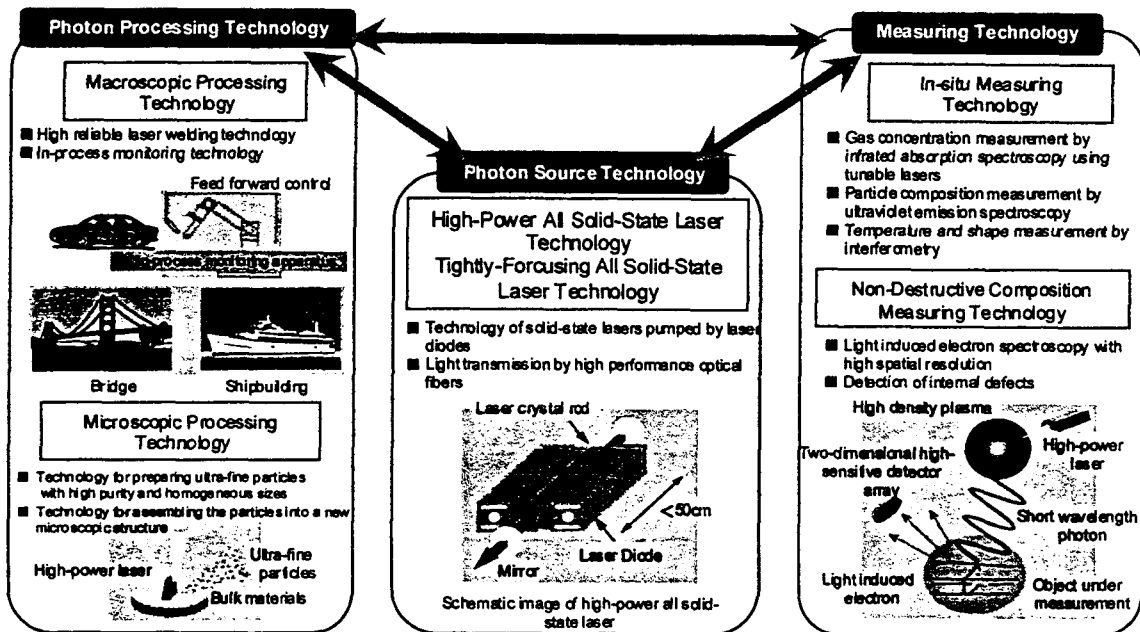


Research Organization



FANUC Laser Lab.

"Advanced Photon Processing and Measurement Technologies"



“High-power All Solid-State Laser Technology”

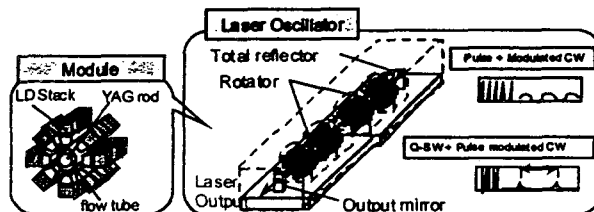
Development of a high-efficiency and high-power all solid-state laser pumped by laser diodes (LD)

Objective:

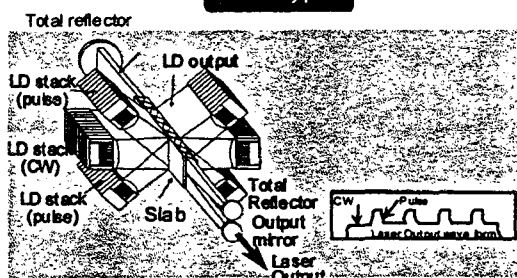
- Volume of Laser Head $\leq 0.05\text{m}^3$
- Output power $\geq 10\text{kW}$
- E/O Efficiency $\geq 20\%$

Impact:

- Introducing Lasers into material processing and machining
- An effective tool for such high-power laser processing as welding, cutting and drilling etc.



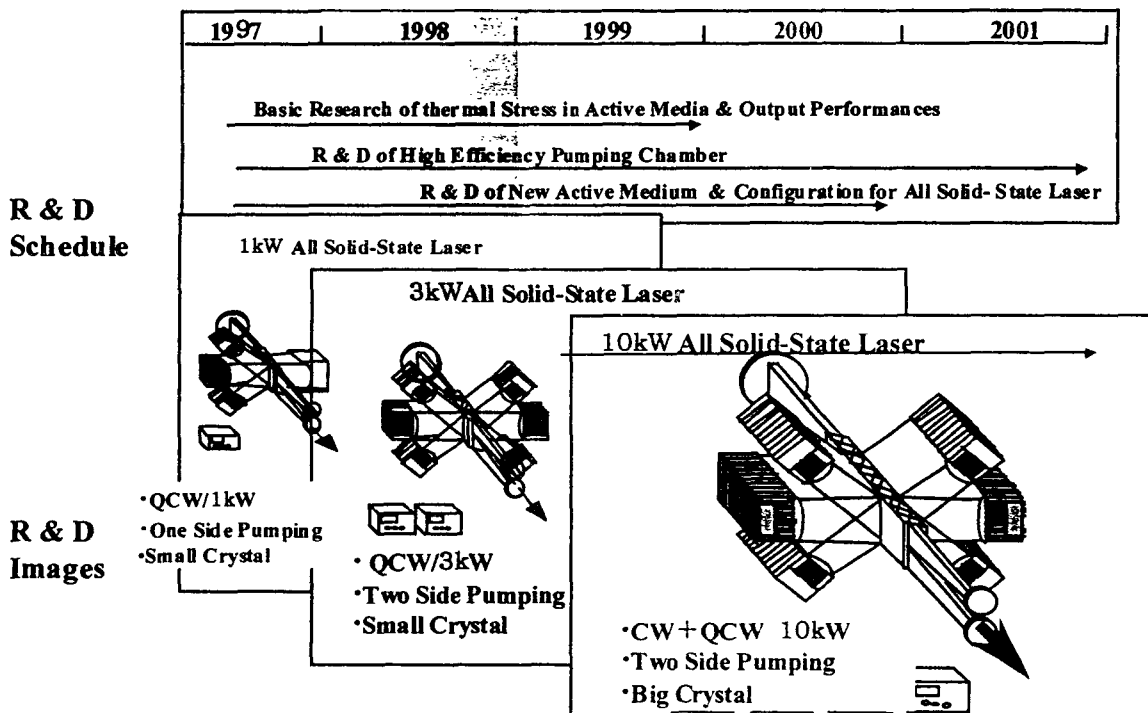
Rod Type



Slab Type

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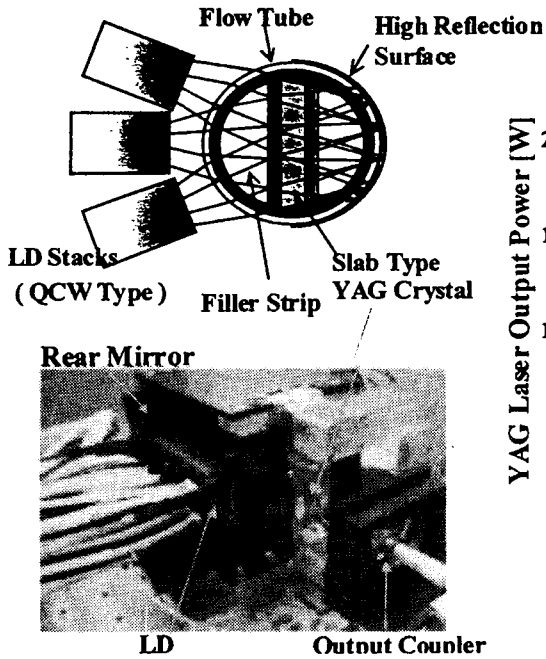
R & D Schedule of 10kW All Solid-State Laser



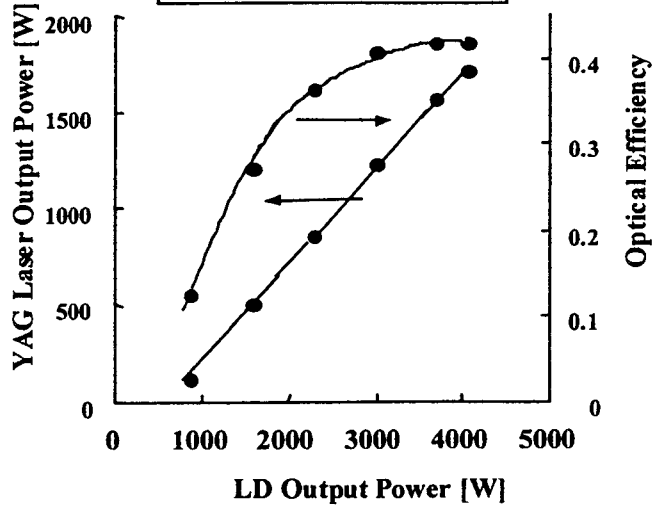
Schematics & Characteristics of LD Pumped YAG laser

Optical Efficiency = 42% / Best Efficiency in the World

Output Power = 1.7 kW / Maximum Power in Japan (at Room Temperature)



Average Power : 1.7 kW
Optical Efficiency : 42 %
Peak Power : 7.3 kW



FANUC Laser Lab

Factory in the near Future

