Laser Technology Being Developed By The Armed Forces

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For Professor Perkins

Abstract

This paper is about the military trying to harness laser technology for it weapons defense program. Many corporations are working together to try and provide soldiers and citizens with a laser that can shoot down missiles and other projectiles with out causing collateral damage. This will be a great asset to the United States once the technology is sufficient and abundant. The one obstacle that is being overcome is the cost. Developers are trying to find a way to lower the cost so that all military personal can afford and obtain its uses.

Lasers

A laser, short for Light Amplification by Stimulated Emission of Radiation, is a very intense, highly directional beam of light. A laser is commonly produced by "exciting" the atoms or molecules in a material in a very controlled manner until they emit photons, or packets of light, in a very organized or coherent fashion.

In chemical lasers, the excited species are formed by a chemical reaction and the energy provided to the system is stored as chemicals. In a solid state laser, the excited species is formed by optical excitation and the energy is provided to the system electrically. This electrical energy can be stored in batteries, flywheels or in fuel for generators. In both cases a population inversion is formed, which allows stimulated emission. Optical extraction occurs using an optical resonator, which can be as simple as a pair of mirrors surrounding the excited gain medium.

A laser is to a common light bulb what a marching band is to a random group of people. A laser's light waves are coherent, i.e., they travel in the same direction at the same time with the same wavelength, allowing the beam to propagate great distances across space with minimal "spreading out" or loss of intensity. With the aid of high precision optical systems, high-energy lasers can deposit intense amounts of light energy (heat) on objects at distances up to thousands of kilometers away.

Chemical Lasers

Chemical lasers are devices whose excited species are formed by chemical reactions. Northrop Grumman has developed two types of chemical lasers – hydrogen fluoride/deuterium fluoride (HF/DF) and chemical oxygen iodine laser (COIL) (ABL YAL 1A Airborne Laser, 2008, par 14). Both types of lasers have demonstrated significant power levels and are being or will be operated at megawatt-class output power. These types of lasers release their waste heat with their effluent and their beam quality is excellent. The make up of the schematic can be seen in Figure 1 (Kopp, 2008)

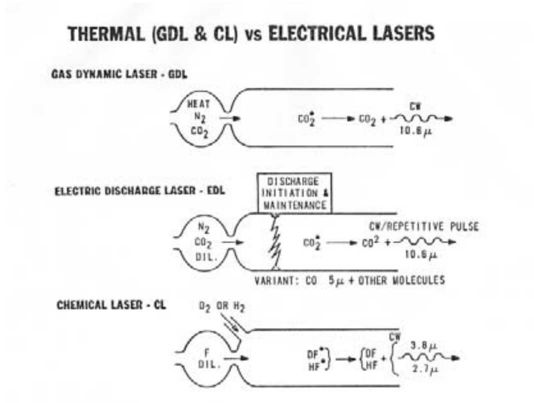

Figure 1: Chemical Laser (Kopp, 2008)

Solid State Lasers

Solid-state lasers (SSLs) use a crystalline or glass material doped with an ion, which is the lasing species. These lasers use flash lamps or diodes to pump the ions to excited levels, which then emit radiation. The first laser, a ruby laser, is an SSL. Recently, these lasers have been scaled to higher power levels for a variety of government and commercial applications. The most common SSL is based on neodymium (Nd) doped into crystals such as Yttrium Aluminum Garnet (YAG). Nd: YAG lasers emit radiation at 1.06 m m, an excellent wavelength for transmission through the atmosphere.

Although currently not as powerful as their chemical counterparts, solid-state lasers are well-suited to a wide variety of defense missions - from destroying incoming threats to illuminating targets, from air defense to mine destruction, from ship protection to electronic warfare. This versatile technology also simplifies field logistics and operations, and is readily adapted for use aboard a wide range of air-, land-, sea-, and space-based platforms.

The Threat Stops Here

Air defense threats are a serious problem. The growing list of proliferating threats includes short range rockets, artillery projectiles, ballistic missiles, UAVs, air-to-ground munitions, and cruise missiles.

Countering short range and late-detection threats with confidence requires a terminal defense system that is fast, accurate and capable of close-in kills with no collateral damage to friendly assets (M-THEL Technology Demonstration Program, 2004, par 8). It requires a system that can engage and kill threats with high kill probability and a deep magazine; that is easy to reload and therefore can fire almost continuously.

Laser Defense Systems Have Come of Age

The Tactical High Energy Laser Advanced Concept Technology Demonstrator (THEL ACTD) was designed and built by a Northrop Grumman-led team. Now being used as the THEL Test Bed, THEL has been proving laser defense system capability since June 2000, when it began shooting down Katyusha rockets.

From the earliest days of modern warfare, the only way to escape an incoming artillery shell has been to find a bunker. In late 2002, the THEL Test Bed made history when, in a remarkably short time, the system was upgraded and began shooting down artillery shells in flight. In only a few days of testing, THEL shot down multiple projectiles, highlighting its potential to change the nature of warfare as it continues to engage new threat types.

This remarkable success was made possible by Northrop Grumman’s disciplined approach to design, integration and testing of this revolutionary system. THEL does not depend on exotic or unproven technologies. It was designed from the beginning as an operational laser weapon demonstrator, not a “white coat laboratory system.” The result: it’s real and it works – after nearly four years of field operations, and after shooting down dozens of threats, it continues to operate reliably, engaging new threats it was not originally designed to engage.

How Laser Works

The THEL is a laser weapon jointly developed by the US and Israel, with the program initiated in 1996. The THEL is to be built in two configurations, the static baseline THEL and relocatable Mobile THEL (MTHEL).

The design aim of the THEL systems is to provide a point defense weapon which is capable of engaging and destroying artillery rockets (Katyushas), artillery shells, mortar rounds and low flying aircraft.

The THEL demonstrator was trialed repeatedly between 2000 and 2004, destroying 28 122 mm and 160 mm Katyusha rockets, multiple artillery shells, and mortar rounds, including a salvo attack by mortar.

The demonstrator THEL system was built around a deuterium fluoride chemical laser operating at 3.8 microns wavelength (M-THEL Technology Demonstration Program, 2004, par 9). The combustor in this laser burns ethylene in toxic and corrosive Nitrogen Trifluoride gas to produce the excited deuterium fluoride lasing medium, which is then mixed with deuterium and helium, and fed into expansion nozzles similar to that of other chemical lasers, like the carbon dioxide GDL and COIL (Kopp, 2008, par 110). A complex exhaust diffusion and pressure equalization system must be used, including a neutralization stage to soak up the highly corrosive and toxic deuterium fluoride exhaust efflux gas.

The first deuterium fluoride laser to be trialed was the US Navy's MIRACL, or Mid-Infrared Advanced Chemical Laser, which was coupled to the Sea Lite Beam Director optical turret. This research system was trialed extensively since 1983 at the High Energy Laser Systems Test Facility (HELSTF Directorate) at White Sands in New Mexico (Kopp, 2008, par 89). This was a Mega Watt class weapon.

The THEL program yielded excellent trial results, using phased array radar to track incoming targets and direct the beam. Unlike the ABL, the THEL is a relatively short range weapon used for the terminal defense of a local area, not unlike a point defense SAM or AAA system.

The sheer bulk of the demonstrator made it impractical for operational deployment, leading to the second generation MTHEL system. MTHEL was to initially have been in three semitrailers, but now appears to have been repackaged into a single container sized semitrailer. A prototype was intended to be deployed by 2007, but more recent reports indicate funding difficulties and thus uncertainties in timelines. This process is easily understood by looking at (Figure 2 below).

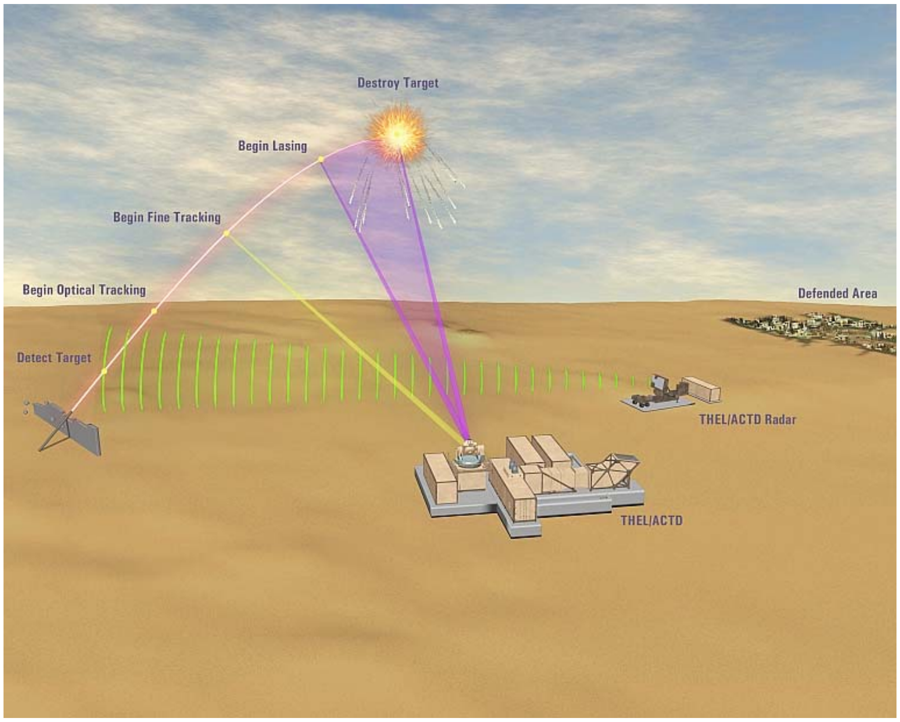

Figure 2: THEL engagement scenario (Kopp, 2008)

The Players

The THEL/MTHEL system was developed by a team including TRW/Northrop-Grumman, Ball Aerospace, Elbit/El-Op, IAI/Elta who developed the radar and fire control system, RAFAEL and Tadiran. (Staff Writers, 2007, par 6) Boeing has also been in the hunt for a contract with the United States that is reported to be around a budget of six-hundred million dollars.

Strengths

- Cost efficient way for defense once developed
- Quicker response against missiles, mortars, and other projectiles
- Reduces innocent casualties

Weakness

- Cost a lot to develop
- Has a lot of testing before implementation
- Not everyone is on board with this technology

Summary

With all the progress and testing being made, it seems that this is a defense weapon the United States is eager to have. If testing keeps proving the laser is as good as it is, I see the military using this technology on a regular basis by the year 2013. The systems will be estimated at a cost of 25 million each. This just shows how much technology is growing and could be used in any field.

References

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