

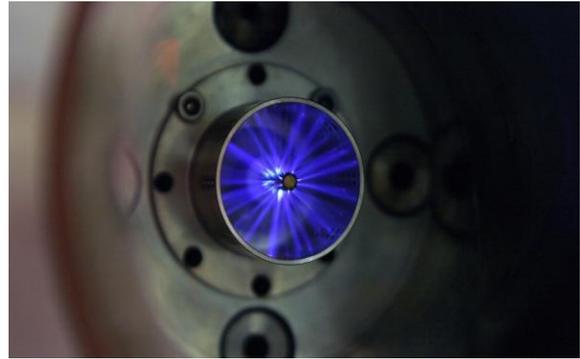
MOTORTREND Frank Markus, May 19, 2020

<https://www.motortrend.com/news/july-technologue-low-temperature-plasma-ignition/>

## So Long, Spark Plugs: Low-Temp Plasma Ignition Might Be the Future

**Cutting-edge tech aims to increase efficiency and reduce emissions.**

When you boil it down, improving average fuel economy is super simple: Burn less fuel in the cylinder when cruising. Toward that end, engine developers have toiled to make lean mixtures work since way before Chrysler's Electronic Lean-Burn System of the mid-'70s. But getting such mixtures to ignite via the spark plug (as in engines since the Model T) has been problematic. Now Torrance, California, startup Transient Plasma Systems is proposing a low-temperature plasma ignition system that it claims can replace the spark plug.



**Non thermal plasma viewed inside a combustion simulation chamber.**

### How Do Traditional Spark Plugs Work?

Here's how traditional spark plugs work: Energy generated by a coil builds across the spark plug's air gap until the energy potential ionizes gases in the gap. This causes the gases to become conductive, resulting in a current spike and a momentary flash of hot plasma—like a tiny lightning bolt. A minuscule percentage of the energy used to create that spark ends up thermally igniting the fuel mixture, which then must propagate throughout the cylinder.

### How Does a Transient Plasma System Differ?

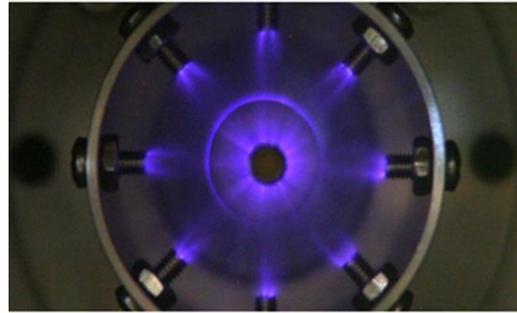
TPS proposes employing a different kind of plasma to initiate combustion in a completely different way. Leveraging recent advances in solid-state high-voltage switching capability, voltage similar to that built up in an old-fashioned coil is summoned in a matter of 10-50 nanoseconds and dispersed not across a discrete gap but rather in streamers and sheets between an electrode and the plug's peripheral housing.

Megawatts of power generate this low-temperature plasma, but at millijoules of energy. Fully half of that energy gets expended, shattering the bonds holding oxygen molecules together and accelerating the individual oxygen atoms so that they attack and ignite the fuel far more quickly and at far lower temperatures.

Testing on a research engine burning ethylene at Ohio State University found that such ignition systems "demonstrated that chain reactions of radicals generated by the plasma reduce ignition time by up to two orders of magnitude and ignition temperature by up to [540 degrees]," according to a paper published by Plasma Sources Science and Technology. "These results provide additional evidence of the non-thermal nature of low-temperature plasma-assisted ignition."

Let's unpack that result. The super-high-speed ignition means less waiting for the flame front to propagate across a dilute mixture and a greater likelihood of burning all the fuel. The lower combustion temperature means far less formation of NO<sub>x</sub> and far less waste heat generated—so more of the fuel energy ends up propelling the vehicle.

The system has since been tested by Argonne National Labs in a Cummins I-6 natural-gas engine, where it demonstrated improved brake thermal efficiency, reduced CO and NO<sub>x</sub> emissions, and an ability to run lots of exhaust-gas recirculation.



**Laboratory demonstration of the effect of nano pulse discharge ignition on multiple electrode spark plug simulator.**

Although TPS ignition can ignite air-fuel mixtures as lean as 25:1, that much excess air still complicates emissions control, so the goal is to run stoichiometric mixtures diluted by lots of excess inert exhaust gases. (It's worth mentioning, however, that TPS is at work on another application of this technology to zap particulates and bust up NO<sub>x</sub> like it does O<sub>2</sub>.)

Fear not, performance fans. The TPS ignition can also boost power. Speedier combustion enables reduced spark advance, so less combustion happens while the piston is still moving up in the cylinder, leaving more of the combustion pressure to turn the wheels.

## TPS Ignition Pros

Here's what I like most about TPS ignition: The system drops right in, replacing today's coils and spark plugs, and its benefits are additive to current technologies like turbocharging and hybridization.



According to TPS co-founder and CEO Dan Singleton, fuel economy benefits should run between 10 and 15 percent across a complete city driving cycle, and the price is now poised to undercut what similar technologies promising such gains cost. His company recently completed an \$8.5 million Series A funding round and is in talks with "several OEs in Europe, Asia, and the U.S."

There's plenty of development and reliability work yet to be done, and these plasma plugs cannot tolerate a resistor core, so other shielding will be required to prevent radio interference. But I'm bullish on plasma's prospects for extending the combustion engine's lease on life.