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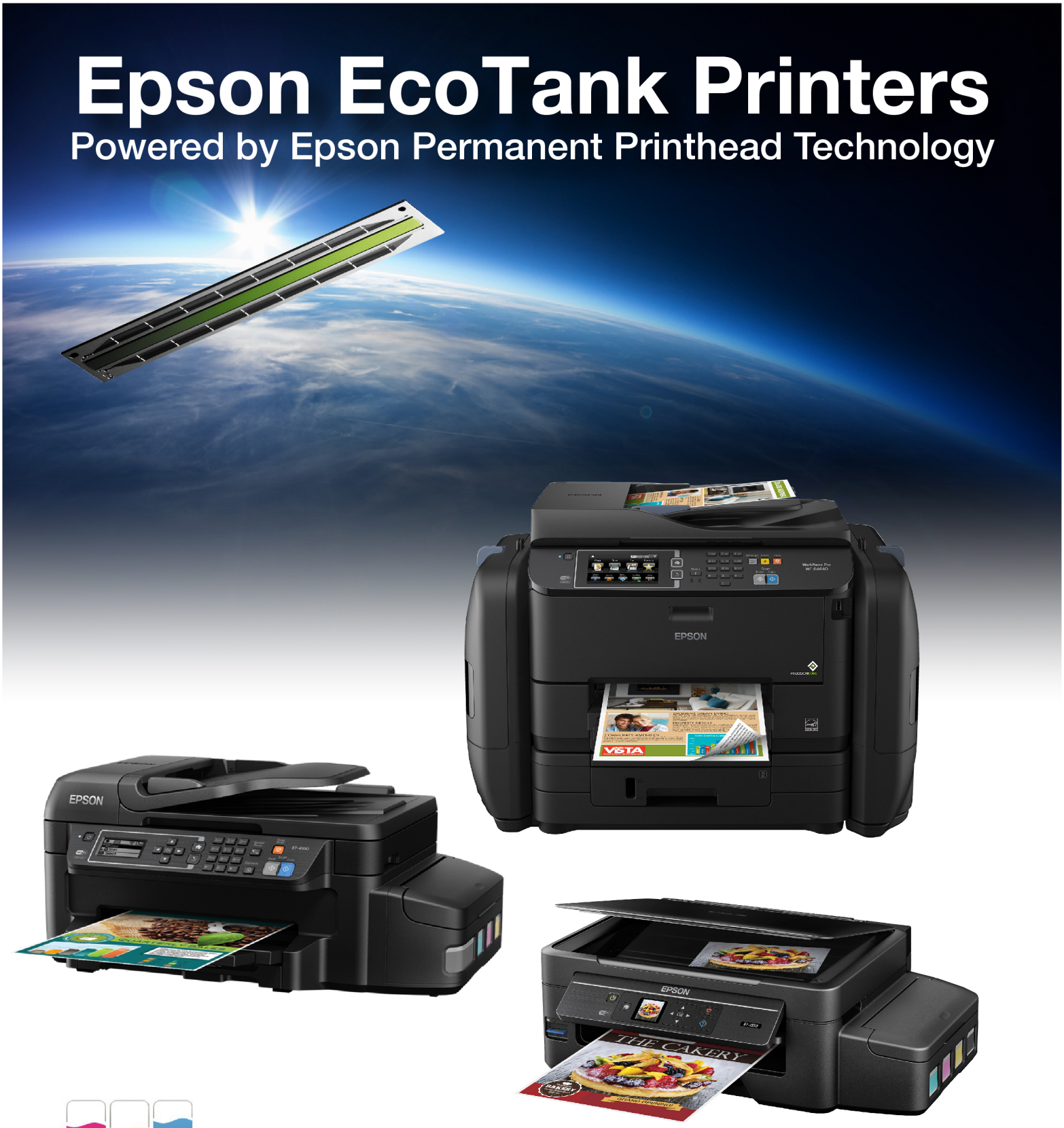
Epson EcoTank Printers

Powered by Epson Permanent Printhead Technology



ecotank

Contents

For more about how the PrecisionCore print chip extends the Epson tradition of delivering outstanding color quality at high speeds, see the white paper PrecisionCore Next-Generation Inkjet Technology.

Photo credits

Figures 1 and 2 of Dawn mission and engines: NASA/JPL-Caltech

Figure 3 of typical chemical rocket: NASA/Bill Ingalls

Figure 13 of Pierre and Marie Curie: Smithsonian Institution Archives

Introduction

This white paper describes the innovative technologies built into a new category of supertank printers from Epson, called EcoTank®.

Epson Expression ET-2550

The EcoTank printer portfolio grew out of Epson's investment of hundreds of millions of dollars in printhead technology over the past 20 years.

The EcoTank design combines a permanent printhead with a high-capacity tank with long-lasting ink supply.

While delivering outstanding Epson print quality, this solution saves customers a significant amount of time, money, and frustration. And EcoTank printers elevate the inkjet printer from a mere tool for home or office into a trusted companion for a long and productive journey.

Epson WorkForce ET-4550

Summary of innovations

The EcoTank portfolio leverages three significant innovations:

- **Cool, long-life ceramic crystals** that pump ink without the hot, shorter-life resistors in disposable thermal inkjet printheads
- **Long-life nozzles with built-in maintenance procedures** to clear away dirt, unclog misfiring nozzles, and ensure longer life
- **Superior ink** for brighter colors and longer life of the printhead

Epson WorkForce Pro WF-R4640

These three innovations combine to create a printhead that will deliver years of reliable service.

The EcoTank designers have found the optimum configuration of many different elements—crystals, nozzles, maintenance, and inks—to create an advanced printhead.

Unlike disposable inkjet cartridges that must be replaced often, Epson's printheads are permanent, designed for the life of the printer.

When is a printer like a space probe?

In 2007, the NASA space probe Dawn blasted off with an ambitious mission: To be the first probe ever to orbit two different bodies beyond Earth.

As shown in Figure 1, Dawn's mission took it first to the asteroid Vesta, and then on to the dwarf planet Ceres, both in the faraway asteroid belt beyond Mars. All told, Dawn has now traveled close to 3 billion miles.

To do this, Dawn was equipped with three ion thruster engines designed to run many times longer than any traditional rocket engine. These ion engines are roughly 10X as efficient as chemical rockets, in terms of thrust per pound of fuel.[1]

Designed for efficiency and reliability over the long haul, Dawn's engines are still working today, more than eight years after launch.[2]

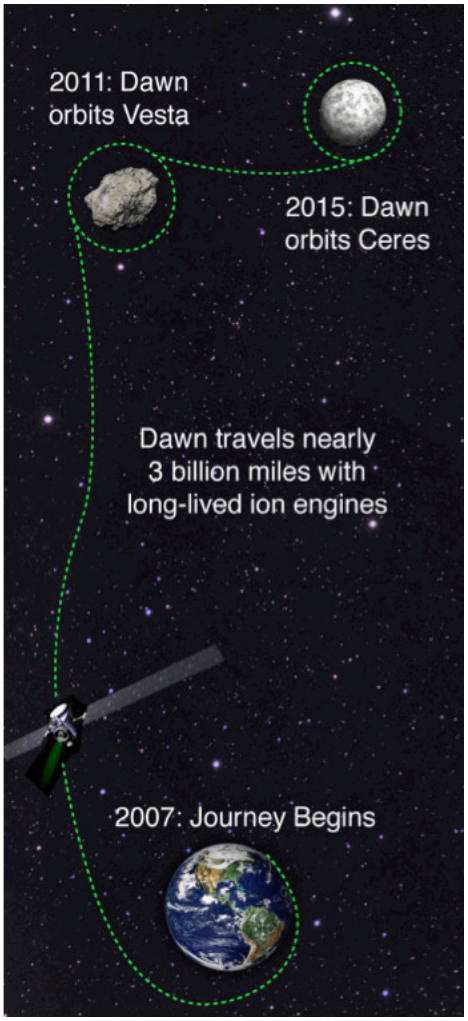


Figure 1: The long-life ion engines on the Dawn spacecraft have operated for eight years now—many times longer than any traditional rocket.

Precise and reliable engines

Imagine your life since 2007, the length of Dawn's mission to date. How many printers have you bought, used, fussed with, and ultimately outgrown during that time?

In the past 8 years, millions of inkjet printers from different manufacturers have been sold in North America. But none brings together the unique set of advanced technologies, convenience, and economy represented by the EcoTank portfolio.

Just as Dawn's ion thrusters are different from traditional rockets, Epson printheads are different from thermal inkjets or bubble jets.

Just as Dawn's long-lasting fuel supply opens up new possibilities for space travel, EcoTank's long-lasting ink supply opens up new possibilities for economical and convenient color printing.

With the launch of the EcoTank portfolio, Epson has transformed the inkjet printer from a mere tool for home or office into a reliable companion for your journey.

EcoTank today and tomorrow

As shown in Figure 2, every Epson printer features an engine that has proven precise and dependable.

After wide acceptance in other regions, the EcoTank supertank printers are now being introduced in North America.

At introduction, the EcoTank portfolio includes five models with different features for different users including consumers, home offices, and small businesses. Each product has different specifications and a different price point from the rest.

In future, the EcoTank portfolio will grow to offer further models with advanced features that continue to deliver economy, convenience, and worry-free operation.

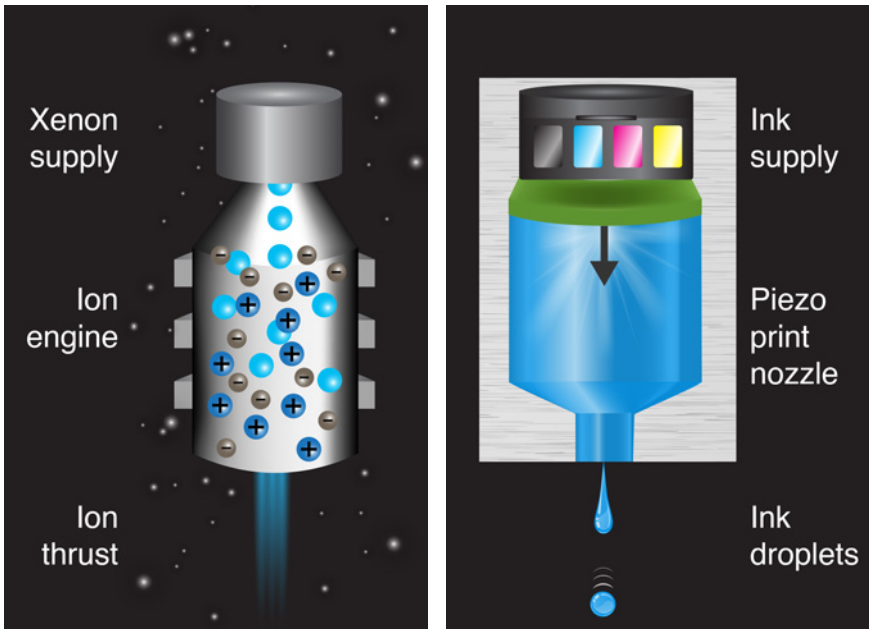


Figure 2: Artist's renditions of Dawn ion thrusters (left) and Epson EcoTank piezo printing system (right). Just as Dawn's long-lived fuel supply opens up new possibilities for space exploration, EcoTank's long-lasting ink supply opens up new possibilities for color printing.

EcoTank innovation #1: Cool, long-life ceramic crystals

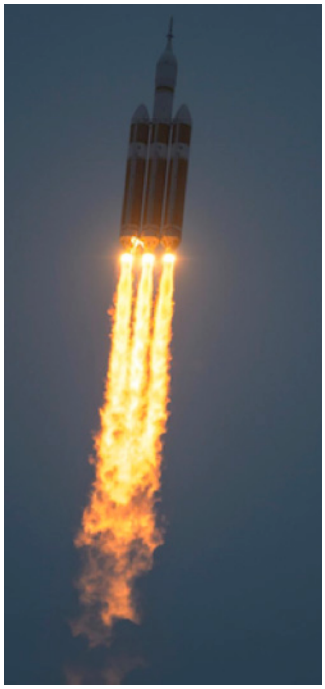


Figure 3: Typical chemical rocket launched by NASA.

As shown in Figure 3, all chemical rockets use the same basic design: Fuel and oxygen mix to produce a controlled explosion, expanding gas blasts out the nozzle, and the rocket is pushed ahead.

But in a very short time, the fuel is all gone, the nozzle is pitted and burnt, and the spent rocket section drops away, discarded.

The payload continues on by itself, like the probe that recently flew past Pluto. Dawn's long-lasting fuel supply lasts for years, enabling it to explore more than one target.

Printing with vaporized ink: hot and explosive

Much the same as a chemical rocket, a thermal inkjet or bubble jet printhead is subject to “severe mechanical stresses” including heat higher than the boiling point of water (212° F) and extreme negative atmospheric pressures.[3]

In this design, electricity heats up thousands of thin resistors submerged in ink, as shown in Figure 4. When the resistor is hotter than the boiling point of water, a bubble of gas forces a drop of hot ink to spray through the nozzle on to the paper. In effect, the resistor vaporizes the ink in the nozzle chamber.

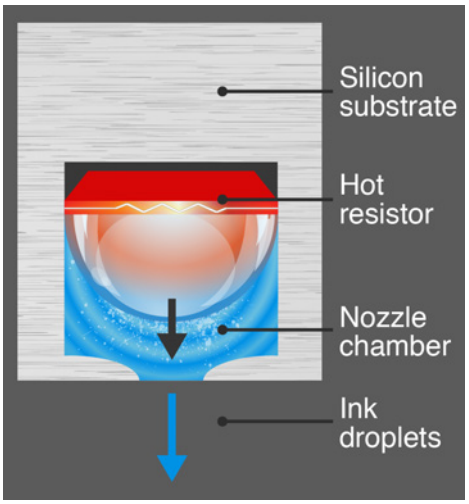


Figure 4: Artist’s rendition of how thermal inkjets use hot resistors that boil the ink. Thermal resistor is only 1 micron thick, but shown thicker for illustration purposes. Printhead nozzles vary by manufacturer and model.

The whole cycle takes less than 30 microseconds. But as each resistor heats up and cools down over time, damage accumulates. Resistors are stressed, protective coatings can be weakened, metals warped, and the bonding between materials loosened.

Another problem: Boiling the ink creates a residue of plaque that builds up on the hot surfaces of the printhead. This plaque can clog the tiny nozzles, typically narrower than a human hair, or less than 40 microns across.

Plaque also adds more insulation around the resistors, so they must get even hotter to fire the nozzle. This adds more stress that further shortens the lifespan of a thermal printhead.

Yet another problem: Micro-erosion. The intense heat and explosive force of the tiny bubbles of boiling ink are enough to wear away microscopic bits of metal, leaving the thermal inkjet nozzles pitted and scarred.

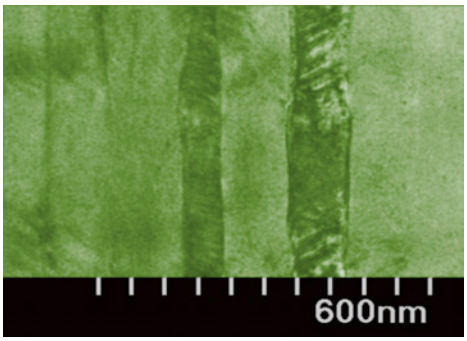


Figure 5: The piezoelectric crystal at the heart of Epson's permanent printheads, based on an actual microphotograph enhanced and colorized.

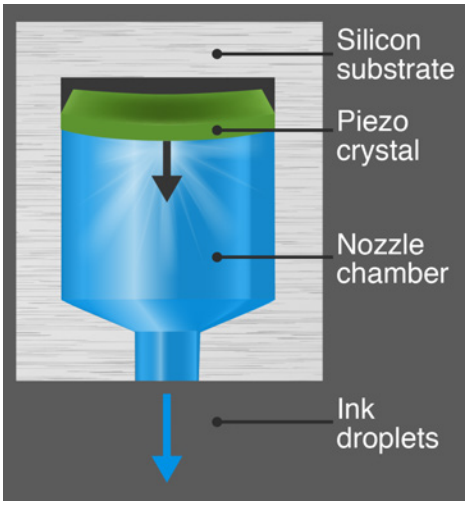


Figure 6: Artist's rendition of how Epson ink-jets use cool ceramic crystals that pump the ink. The longer nozzle creates more precise drops and places them more accurately. Piezo crystal is only 1 micron thick, but shown thicker for illustration purposes. The volume of the nozzle chamber spaces in Figures 4 and 6 are not drawn at the same scale.

Over the years, engineers have tried valiantly to solve these problems. A common solution for manufacturers seeking to make thermal printheads more *reliable* has been to make them *disposable*, so that consumers must often replace them.

Printing with piezo crystals: cool and controlled

In the 21st century, chemical rockets aren't the only way to fly—and thermal inkjets that vaporize ink aren't the only way to print.

Just as there's something different at the heart of the Dawn space probe, there's something different inside Epson printheads: A tiny layer of piezo crystals, as shown in Figure 5. These crystals make all the difference.

When an electric charge is applied to this piezo crystal, it changes shape, acting as a tiny "pump" that pushes a drop of ink through the nozzle on to the paper. When the charge is removed, the crystal pops back to its original shape.

As shown in Figure 6, the ink is never heated nor boiled. And since the entire cycle is cool and mechanical—not hot and explosive—the nozzles in a piezo printhead suffer much less pounding and last much longer.

Piezo is better than thermal

Due to the intense heat and pressure generated inside a thermal inkjet, these printheads are designed to be thrown away after a shorter lifespan than a printhead designed to be permanent.

While some thermal printheads have improved to be more permanent, the vast majority now being used are still designed to be disposed along with an ink cartridge.

In contrast, Epson's crystal printheads have never been disposable. With nozzles that can generate billions of precise droplets, Epson printheads are built for a journey that can last many years.

EcoTank innovation #2: Long-life nozzles with built-in maintenance procedures

Dawn wasn't the first spacecraft to use ion propulsion. An earlier probe launched in 1998—NASA's Deep Space 1—used the same type of engine. But after running only 4.5 minutes, those engines failed.

NASA engineers suspected metallic contamination from the launch rocket shorted out Deep Space 1's high-voltage ion grids. By repeatedly restarting the engine, flight engineers managed to clear the contamination and reactivate the grids, so the mission could continue.[4]

Just like a space probe, Epson permanent printheads are designed for extremely precise operations, as shown in Figure 7. This careful design includes built-in maintenance procedures to help the printhead remain in top condition throughout its life.

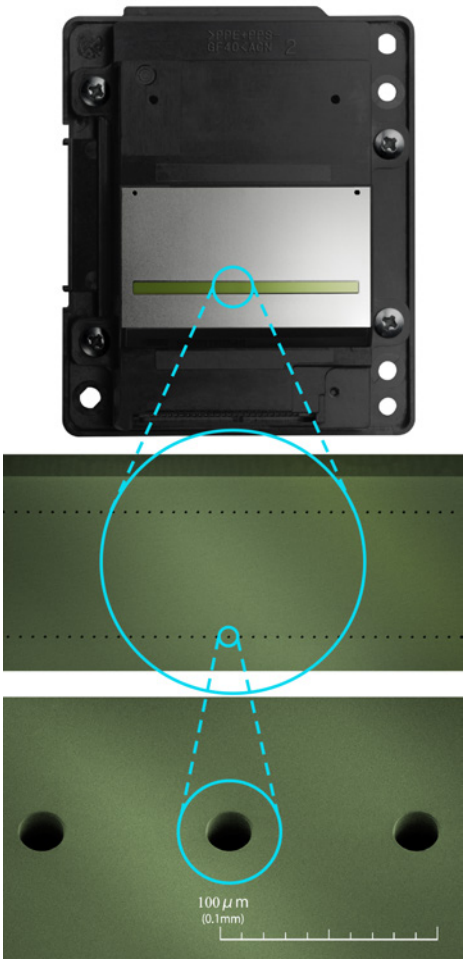


Figure 7: Photos showing precise engineering of the Epson permanent printhead. The PrecisionCore print chip contains 800 nozzles in just 1.3 inches (top). Closeup of one row of nozzles (middle). Closeup of three nozzles (bottom).

Printing can be a dirty business

Everyone wants their output to dry instantly, no matter how much ink is jetted on the media. That means engineers must get the ink to dry quickly on the paper—not on the printhead, where it can lead to clogged nozzles.

And at a microscopic level, the environment where printheads operate is quite dirty.

The biggest source of this "dirt" is paper dust. As both the paper and printhead move, microscopic particles of dust are continuously kicked up from the surface of the paper.

Some of this dust lands where it does no harm. Some lands directly on the printhead. And some lands right inside the tiny nozzles themselves.

This unwanted dust can lead to ink buildup around the nozzles, where it can cause misshaped, misdirected, or slow drops, or even a completely clogged nozzle.

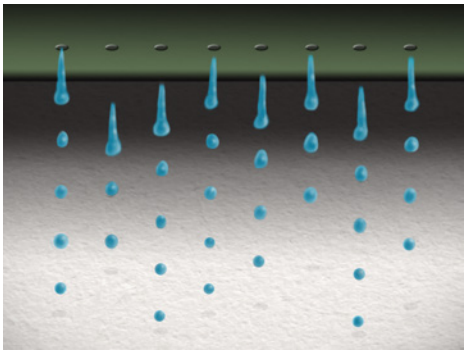


Figure 8: Artist's rendition based on micro-photograph of Epson inkjet printing a test pattern. Epson's built-in maintenance procedures help every nozzle to deliver precise drops up to 50,000 times a second, repeated billions of times.

EcoTank's built-in maintenance procedures

Most inkjet systems are designed to overcome an occasional clogged nozzle. But too many clogs can mean unacceptable output, with dropped dots in text and white lines in color areas.

Several automated processes keep Epson printhead nozzles working:

- *Wiping* removes contaminants from the nozzle array
- *Vacuuming* pulls ink through the printhead for cleaning
- *Expulsion* moves the piezo crystal rapidly to remove any built-up material before it can clog a nozzle
- *Capping* prevents nozzles not in use from drying out

All these measures happen automatically. As shown in Figure 8, these measures work unseen on a microscopic level, eliminating problems before they even appear. This helps to ensure a long life from an Epson printhead.

Of course, you can still print a test sheet and ask your printer to run a manual clean, if needed. While Epson handles the routine maintenance, you remain firmly in control of your printer.

This remarkable feat of engineering is like building a car that can change its own oil, either as needed or on request. This built-in capability further prolongs the life of an Epson permanent printhead.

Delivering speed, precision, and quality

Even though both the printhead and the paper are constantly moving, Epson engineers design printheads so that the drops from a piezo nozzle:

- Form a perfect round dot
- Travel in an exact direction
- Move at an extremely precise velocity
- Be placed accurately on paper

The smallest deformation of a drop, the slightest waver from its intended direction, or the tiniest slowdown in its speed mean a drop reaches the paper in the wrong spot.

Epson has spent more than 20 years and hundreds of millions of dollars in R&D to overcome these challenges. The result is a permanent printhead with controlled piezo pumps and longer nozzles that deliver perfectly round, consistently placed dots up to 50,000 times a second, repeated billions of times.

EcoTank innovation #3: Superior ink to promote longer printhead life

The engineers who created the ion thrusters for the Dawn spacecraft designed the engines to work with the trace element xenon.

- Would some other kind of propellant have worked in those engines? Perhaps.
- Could NASA have saved a few dollars by using some other fuel than xenon? Maybe.
- Would it have made sense to try something else, or switch to a new supplier at the last minute? No way.

Just as Dawn's long-life engines are still running today with the special fuel it was designed to use, **Epson's permanent printheads deliver the best results—and last the longest—with the original inks they were designed to use.**

Ink: a complex mix of ingredients

The superior design of the Epson printheads enables engineers to choose fluids with better all-around properties.

For example, Epson inks are not corrosive, and do not attack the material set in the printhead. Instead, they lubricate the printhead and prolong its life.

And since Epson inks are not boiled, they can use a wider variety of active ingredients in greater concentrations than thermal inkjet inks. For example, in the EcoTank WF-R4640 with DuraBrite® inks, the high concentration of pigment colorants and binders in every drop of ink produces darker, crisper text and more vibrant images on plain paper.

As shown in Figure 9, Epson inks include many other ingredients besides water and colorants.

All these substances are carefully formulated to keep the printhead working in top condition to deliver outstanding printed results for the longest possible time.

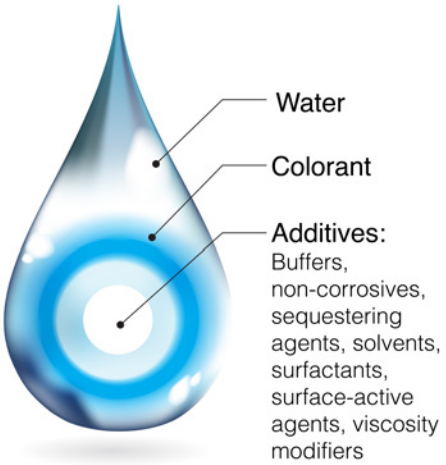


Figure 9: Conceptual view of an Epson ink droplet. Since Epson inks are not boiled, they contain less water and more colorants and other special ingredients that deliver outstanding printed results.

EcoTank delivers cost-effective ink

Every EcoTank printer is shipped with an ink supply that can last for up to two years of printing, without replacing the ink.[5] After that, you can replenish your supply from ultra low-cost ink bottles or packs available from Epson.

Three of the five EcoTank models use dye-based inks formulated to provide outstanding results for home and office. The ET-4550 utilizes pigment black ink for dark and durable text on plain paper. Lastly, the WF-R4640 uses Epson DuraBrite pigment inks for extremely durable prints that resist smudges, fading, and water.

Epson's tradition of precise manufacturing

Inkjet technology goes further than the printhead, maintenance, or ink chemistry. As shown in Figure 10, the mechanism to move the paper and printhead in tiny, precise increments are critical elements of a superior printing system.

Epson has been manufacturing high-quality printer mechanisms for more than 40 years. In recent years, ongoing improvements in these mechanisms have helped Epson printers perform even better and last even longer.

The company's vertically integrated manufacturing model enables Epson to control the quality of every component and to engineer long life into every product. Epson has applied this experience to make every model in the EcoTank portfolio a reliable companion for a long and productive journey.

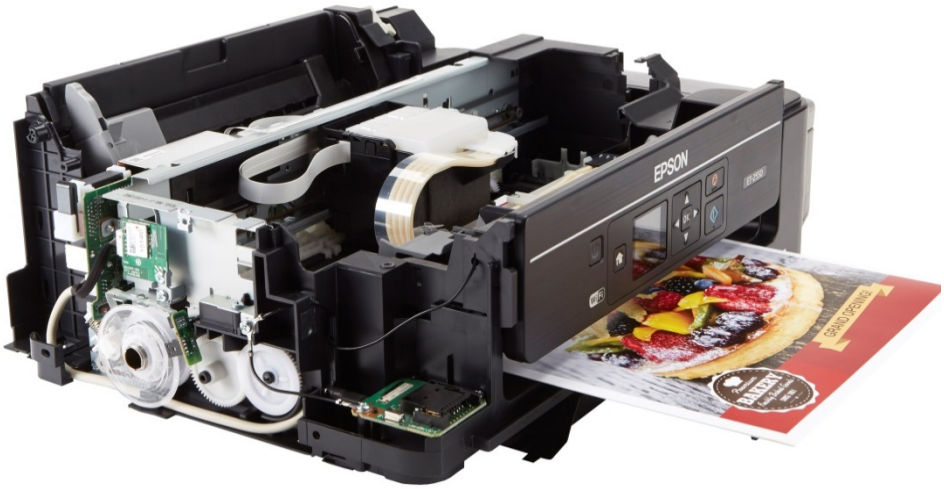


Figure10: Interior view of the Epson EcoTank Expression 2550. Epson has been manufacturing high-quality printer mechanisms for more than 40 years.

Key customer benefits of EcoTank

EcoTank printers combine a permanent printhead with a high-capacity tank with long-lasting ink supply. The innovations in this portfolio combine to deliver dramatic customer benefits over a typical cartridge printer:

- Much lower cost, over time
- More convenience, with no replacing cartridges
- No more hassles from running out of ink

Figure 11: While one set of standard cartridges for a typical inkjet prints only about 165 pages (above), one set of EcoTank ink bottles prints up to 4,000 pages[6] (below).

Much lower cost, over time

Buying a printer like the EcoTank ET-2550 costs more up front than buying a typical cartridge printer. But as shown in Figure 11, that EcoTank printer includes enough ink to print up to 4,000 pages[6] —equal to about 20 sets of ink cartridges[7]—so you'll soon be saving money.

An EcoTank printer is a wise choice for those with heavier everyday uses such as families with kids who print school projects, restaurants that print daily menus, or office workers who print presentations and proposals.

With such low-cost printing, you can forget about "print rationing." You can print whenever it makes your journey faster, better, or more convenient.

With an EcoTank printer in your home or business, you'll encourage your kids and employees to print in color whenever it helps them—instead of worrying about the cost, or wondering how soon you'll have to run out to buy yet another cartridge.

More convenience, with no replacing cartridges

Let's face it: Changing cartridges in an inkjet printer is a chore. With EcoTank, you don't have to. And you don't have to find the proper way to recycle all those spent cartridges. This adds up to a major boost in convenience for EcoTank users.

People have been talking about "the paperless office" since 1975.[8] But everyone needs to print something for home, school, or work. The real question isn't, "To print or not to print?" but "How can I do the printing I need with less waste?"

All printers use the same amount of paper and about the same amount of ink. The key difference is how much waste you create every time you replace the ink in your printer.

Not to mention the gasoline you burn driving to the store—or having replacement cartridges delivered.

Epson EcoTank printers use less packaging and create less waste, which adds up to more peace of mind for customers, plus a lot more convenience.

No more hassles from running out of ink

Just as your car never runs out of gas in the garage, your printer never runs out of ink unless you're using it. And it always runs out at the worst possible time, just when:

- You need a few copies of your slides for a meeting
- You need a couple more resumes for the big interview
- Your need 80 menu inserts ready by 8 am
- Your child has a school report due the next morning

As shown in Figure 12, every EcoTank 2550 printer comes with about 20 sets of cartridges worth of ink.[6] This means less frustration from running out of ink, and the peace of mind that you can meet all your printing needs.

Figure 12: Printing 4,000 pages with a typical inkjet means replacing about 20 sets of cartridges[6] (above) while EcoTank users can print as much with only one set of ink bottles (below)—meaning far less waste and frustration.

Conclusions

This white paper describes the innovative technologies built into a new line of desktop printers from Epson, called EcoTank:

- Cool, long-life ceramic crystals that pump ink
- Long-life nozzles with built-in maintenance procedures
- Superior ink to promote longer printhead life

The EcoTank product design combines a permanent printhead with a high-capacity tank with long-lasting ink supply. This saves customers a significant amount of time, money, and frustration… and elevates EcoTank from a mere tool for home or office into a reliable companion for a long and productive journey.

This supertank design is only feasible with piezo printheads from Epson designed to be permanent, not disposable.

To find out more about the Epson EcoTank products, visit www.epson.com/ecotank

Tech focus: The history and future of piezo technology

Figure 13: Pierre and Marie Currie shared a Nobel Prize for Physics in 1903.

French scientist Pierre Curie was only 20 years old when he began studying crystals with his older brother Jacques.

Working with the simplest tools such as magnets, wire, and tinfoil, in 1880 they discovered that applying pressure to certain crystals—quartz in particular—created a tiny electric current.

The next year, they confirmed that this phenomenon worked in reverse: Placed in an electric field, the crystals were compressed.[9] The brothers had demonstrated the "piezoelectric effect"—named from the Greek word meaning "to press."

The Curie's went on to further pioneering research, with Pierre and his wife Marie sharing a Nobel Prize for Physics in 1903.

Research continued into piezo crystals

One of the first practical applications of the piezoelectric effect was sonar. By 1917, ultrasonic quartz transducers were being used to map the ocean floor with sound waves.

During the 1940s, American, Soviet, and Japanese researchers discovered ceramic materials with even stronger piezoelectric properties up to 100x more than natural crystals.

This touched off a wave of innovations that lead to powerful sonar, miniature sensitive microphones, and other items still used today.

By 1954, everyone's preferred choice for piezoelectric material was PZT. As shown in Figure 13, when a voltage is applied to a PZT molecule, the electric field forces the central atom to move, causing the PZT crystal to change shape.

Remove the charge, and the crystal pops back to its original shape. It seems that a PZT crystal can be flexed this way indefinitely, certainly more than 100 billion times.

The Barium Titanate Research Committee

Piezoelectric researchers in the United States worked in isolation in secret company labs. Yet in Japan, several companies and universities formed a cooperative association, known as the Barium Titanate Application Research Committee.

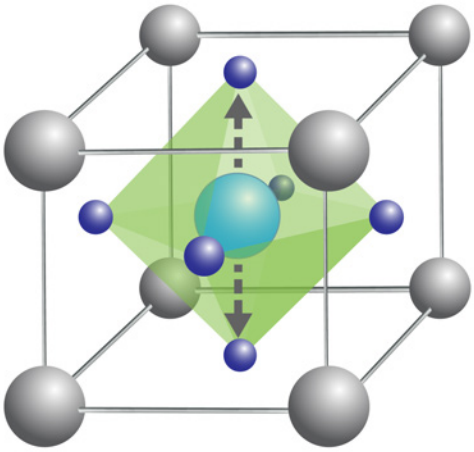


Figure 14: Structure of the PZT molecule, the preferred choice for the piezo industry since the 1950s, showing the light blue central atom that moves under an electric charge.

Starting in 1951, this organization overcame many technical and manufacturing hurdles, and helped to define new markets for the technology.

Among these were highly accurate vibrating crystals that revolutionized the wristwatch, with Epson's predecessor Suwa Seikosha among the early innovators in the field.

In 1984, Epson produced its earliest piezo-based printer, the SQ-2000. This product was notable for its low noise, high speed, and clear print.

In March 1993, Epson harnessed this amazing technology in its first multi-layer piezo printhead for the Epson Stylus 800. This ground-breaking printer offered excellent firing uniformity, with output virtually indistinguishable from a laser printer.

Since that time, Epson has invested hundreds of millions of dollars in R&D on piezo inkjet printers.

In 2014, Epson launched the next-generation PrecisionCore printhead, based on piezo crystals only 1 micron thick. PrecisionCore is a highly scalable technology suitable for products ranging from desktop printers to industrial printing systems. Every PrecisionCore printhead creates ultra-precise drops of ink that deliver sharp text and vibrant images.

An exciting future

Building on its key advantages of precision, flexibility, and durability, piezo inkjet printing is moving into many new applications.

For example, piezo inks can address a wide array of substrates beyond paper, including plastic, glass, textiles, metal, and clay. This opens up many exciting new possibilities for consumer and industrial products, from labels to packaging.

And since the fluids are never heated, piezo jetting is flexible enough to handle sensitive biological materials to create artificial limbs and organs, and conductive materials to manufacture thin-film screens and circuitry.

With a solid track record behind it, and a bright future ahead, piezo inkjet printing is here to stay.

About Epson America, Inc.

Epson is a global technology leader dedicated to driving innovations and exceeding customer expectations in printing, visual communications, quality of life and manufacturing. Epson's lineup ranges from inkjet printers, printing systems and 3LCD projectors to industrial robots, smart glasses and sensing systems and is based on original compact, energy-saving, and high-precision technologies.

Led by the Japan-based Seiko Epson Corporation, the Epson Group comprises nearly 70,000 employees in 94 companies around the world, and is proud of its contributions to the communities in which it operates and its ongoing efforts to reduce environmental burdens.

Epson America, Inc. based in Long Beach, Calif. is Epson's regional headquarters for the U.S., Canada, and Latin America. To learn more about Epson, please visit www.epson.com.

For the Epson newsroom, visit http://news.epson.com/

You may also connect with Epson America on

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- YouTube (www.youtube.com/EpsonAmerica)

Notes

1: “Frequently Asked Questions about Ion Propulsion,” New Millennium Program, NASA retrieved July 20, 2015 from http://nmp.jpl.nasa.gov/ds1/tech/ionpropfaq.html

2: All facts about Dawn from NASA such as the official mission page at http://dawn.jpl.nasa.gov/

3: J. Stephen Aden, Jaime H. Bohórquez, Douglas M. Collins, M. Douglas Crook, André García, and Ulrich E. Hess, “The Third-Generation HP Thermal Inkjet Printhead,” *HP Journal*, February 1994 retrieved July 20, 2015 from http://www.hpl.hp.com/hpjournal/94feb/feb94a6.htm

4: Marc D. Rayman, Philip Varghese, David H. Lehman, and Leslie L. Livesay, “Results from the Deep Space 1 Technology Validation Mission,” Jet Propulsion Laboratory, California Institute of Technology, American Institute of Aeronautics and Astronautics, Inc., 1999, page 3 retrieved July 20, 2015 from http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/17743/1/99-1185.pdf

5: Based on average monthly print volumes of about 150 pages (ET-2500, ET-2550, ET-4500), 300 pages (ET-4550), and 800 pages (WF-R4640)

6: Yields based on the ISO/IEC 24712 pattern with Epson’s methodology. Actual ink yields will vary considerably for reasons including images printed, print settings, temperature, and humidity. Yields may be lower when printing infrequently or predominantly with one ink color. All ink colors are used for printing and printer maintenance, and all colors must be available for printing.
For more information, visit www.epson.com/cartridgeinfo

7: About 20 cartridge sets estimate based on print yields of the included black and color ink bottles as compared to standard-capacity ink cartridge sets for similarly featured cartridge printers as of March 2015

8: “The Office of the Future,” *BusinessWeek*, June 30, 1975

9: “March 1880: The Curie Brothers Discover Piezoelectricity,” *APS NEWS*, American Physical Society